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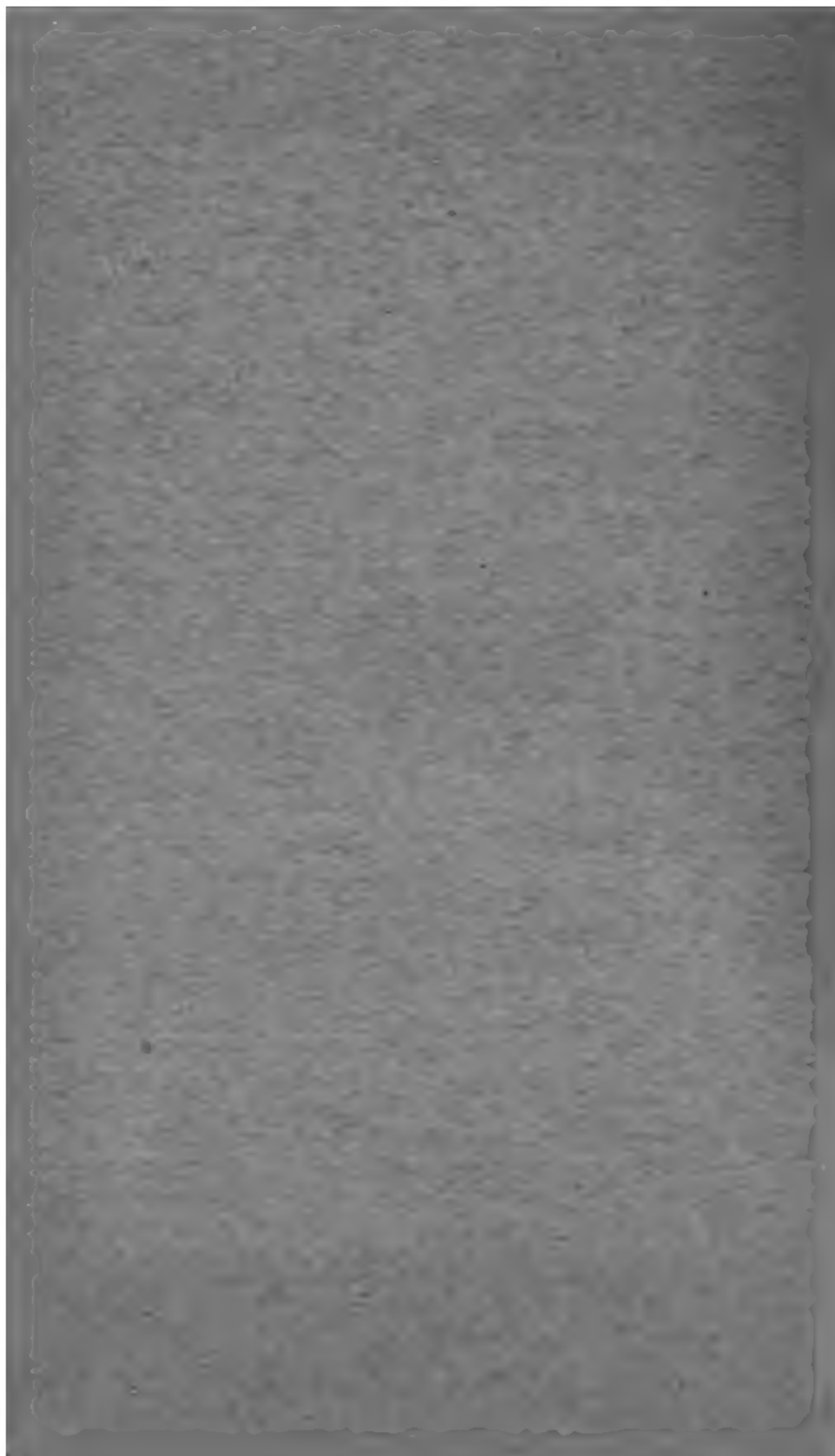
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The first of these is the fact that the
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 has led to a loss of confidence
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 consequent loss of support.
 The second is the fact that
 the government has been unable
 to maintain a stable economy.
 This has led to a loss of
 confidence in the government
 and a consequent loss of support.
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OF THE

From

Indiana Academy of Science,

Jan. 26, 1893

1891.

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PRELIMINARY NOTE.

During the last days of the assembling of the material for this volume and while the volume itself was in press, the Secretary of the Academy was partially incapacitated by sickness. An abstract of the meeting of 1891 has therefore been omitted. It is expected that such abstracts will appear in subsequent volumes. The bibliography of papers is necessarily incomplete, but all information which the editors could secure has been inserted. In the selection of papers to be presented in full, preference has been given to those of permanent local value. On the second page of the cover under the title "Patrons," are given the names of the individuals and business firms who have contributed materially towards the expenses of this publication. To these patrons of science we hereby tender our grateful acknowledgments.

When the editors were selected, it was agreed that they should be at liberty to call in other members of the Academy, specialists in departments not represented on the staff. Accordingly W. A. Noyes was chosen assistant editor in chemistry, Vernon F. Marsters in geology, A. W. Butler in archaeology and ornithology, F. M. Webster in entomology, and Carl H. Eigenmann in ichthyology. The editors wish herewith to make proper recognition of the valuable services rendered by these gentlemen in the preparation of the present volume, which is the first systematic attempt to preserve some account of the work done by the Indiana Academy of Science and to make it available as a connected whole to the members and to the friends of science.

THE EDITORS.

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Active members 121

Total 133

FIELD MEETINGS.

It was fitting that the first "Field Meeting" of the Indiana Academy of Science should be held at Brookville. There the idea of such an organization originated. There the steps were taken, through the Brookville Society of Natural History, by which the scientific investigators of the state were brought together at Indianapolis, December 29th, 1885, to adopt articles of association and effect an organization.

This first Field Meeting began Thursday evening, May 20th, 1886. The Academy was welcomed by Mr. D. W. McKee, President of the Brookville Society of Natural History. President D. S. Jordan responded to his greetings. Dr. John C. Branner delivered an address on "The relations now existing between geologists and the people." The next day was devoted to visiting the localities of interest to the persons attending. Luncheon was served at "Templeton's ford," on the east fork of White Water river. In the deep, clear water of the pool above the ford the baptism took place and the first "Field Meeting" was declared by the president to be a success. Recollections of that day—the first of united scientific work in Indiana, a meeting more successful by far than had been dreamed of, and yet which bespoke the fuller fruition to which the child of our minds should come in later years—can never be effaced.

At night a public meeting was held in the Town Hall. Dr. Jordan delivered an address on "Charles Darwin." He also told "How to go fishing." Dr. Branner gave an account of methods of coral fishing. Dr. P. S. Baker spoke of recent progress in Toxicology. The number of persons attending that meeting, and strange so say, several others, was thirty-three.

The second "Field Meeting" of the Academy began its session at Waveland, Ind., May 19th, 1887. The meeting that evening was informal—thoroughly so. The recollections of it will remain with those who participated, and it would hardly be just to attempt to give an account of the proceedings for the benefit of others.

The following morning the members were driven to "Shades of Death," a delightful spot adjacent to Sugar creek. There the day was spent and luncheon served. Every one had heard of this beautiful spot, shaded, well watered, with its cañons, the cliffs of which were topped with pine and hemlock, and the walls draped with ferns and bedecked with mosses;

its "buzzard's roost;" its lack of snakes, its peaceful dells and shady glens —of all of which "the half has not been told."

At night a public meeting was held at the M. E. church in Waveland, when Dr. T. C. Mendenhall delivered an address upon "Weather Predictions." An informal discussion of the natural features of the region visited was held. C. R. Barnes, J. M. Coulter, W. S. Blatchley and Stanley Coulter spoke of its botanical interest, O. P. Jenkins of the fishes, B. W. Evermann of the birds, A. W. Butler of the reptiles and amphibians, T. C. Mendenhall of the southern limit of the white pine, P. S. Baker and W. W. Byers of the geology.

The following day the members were taken to "Pine Hills," in the valley of Indian creek, about a mile above the locality of the preceding day's explorations. The features of the country were somewhat different from those noticed the day before. A pleasant day was spent and luncheon was served at the club house. At this meeting also there were thirty-three persons.

The third "Field Meeting" was begun at Paoli, Orange county, May 2, 1888. The meeting was held in the public hall and was presided over by Vice President O. P. Hay.

Prof. James E. Humphrey delivered an address entitled "Asa Gray."

Prof. J. M. Coulter gave a lecture on "The Yellowstone Park."

The day following the persons present, thirty-three in number, drove to Wyandotte cave, in Crawford county, going in the way they traveled, about forty miles. The evening and the early part of the night was spent exploring the cave. The next day the party returned to Paoli, stopping at Marengo cave. The journey was a hard one, but it had its pleasures and they were noteworthy. All will remember that meeting, some, in some respects, unpleasantly, others as a season of unusual brightness in their lives. The annals of that meeting are classic to Indiana's scientists. How unfortunate the chronicler cannot always write the whole truth!

At Greensburg, Ind., May 8th, 1889, the fourth "Field Meeting" began. The session was held at 8:30 o'clock P. M. in the rink. Vice President J. L. Campbell presided. Dr. J. P. D. John delivered an illustrated lecture on "Our Celestial Visitors."

The day following was pleasantly spent visiting the Upper and Lower Silurian exposures along Cobb's Fork of Sand creek. After luncheon, which was kindly provided by the hospitable people of Greensburg, the

members went to the Harris City quarries, thence returned to Greensburg. In the evening another session was held in High School Hall. The following persons spoke of some of the observations made during the day :

J. L. Campbell, on Topography.

G. K. Greene and W. P. Shannon, on Geology.

J. M. Coulter, D. H. Campbell and J. C. Arthur, on Botany.

Hon. Will Cumback then gave his impressions of the meeting.

Edward Hughes gave an account of the Amphibians noted.

A. W. Butler spoke of the reptiles.

O. P. Jenkins spoke of the fishes of Cobb's Fork, and was followed by D. S. Jordan, who spoke of fishes also.

Rev. Mr. Torrence and J. P. D. John made appropriate remarks, the latter moving the adoption of a vote of thanks to the citizens of Greensburg for their hospitality, which was voted.

The roll showed twenty-seven persons present.

The next day the members divided, a part going to St. Paul and Waldron, others to Clifty creek. The former spent the day among the fossils of these famous localities, while the latter fished or lounged beside the quiet stream drinking inspiration and absorbing wisdom at the same time. Over a small fire the champion of "vegetable beefsteak" might have been seen, giving instruction in primitive culinary methods as applied to his favorite food, while sitting about were several individuals who discussed the governor's jokes, the *true* name of the stream explored yesterday, and the unaccommodating manner of the fishes who persisted in refusing to be caught, as with rapid flow alike of words and saliva they watched the slowly growing mushroom pile. And thus we remember Greensburg.

The next "Field Meeting" was appointed for Greencastle, where the meeting was called to order in Meharry Hall of DePauw University, at 8 o'clock P. M., May 8, 1890, by Prof. C. A. Waldo, acting president. Prof. C. Leo Mees delivered an address on "Inertia with reference to electricity." Dr. Daniel Kirkwood was elected the first honorary member of the Academy. President J. P. D. John, of DePauw University, extended to the members the courtesies of the university.

The following morning the members, according to previous arrangement, went to "Fern," an interesting spot, where the day was pleasantly spent. In the evening the party returned to Greencastle.

At 8 o'clock P. M. the Academy convened in Meharry Hall with ex-President John in the chair.

J. C. Arthur presented "Some observations on parasitic plants taken at 'Fern.'"

C. R. Dryer gave an account of the "Surface Geology of Putnam county." C. W. Hargitt spoke on "Some observations on Economic Entomology." Stanley Coulter gave some notes on the day's work. D. H. Campbell spoke of the ferns at "Fern." C. A. Waldo referred to the proposed meeting of the American Association for the Advancement of Science at Indianapolis in August next. A vote of appreciation of the kindness and courtesy shown the members of the Academy by the citizens of Greencastle and University authorities was passed. O. P. Jenkins, being called upon, spoke concerning the influence of associations such as the Indiana Academy of Science upon the individual worker. After discussing plans for welcoming and entertaining the American Association the Academy adjourned.

According to appointment, the sixth "Field Meeting" was convened at the Arlington Hotel, Lake Maxinkuckee, May 14, 1891, at 8 o'clock P. M. President Hay occupied the chair. Dr. P. S. Baker delivered an address upon "The Spirit of Scientific Work," for which the thanks of the Academy were tendered him. The Executive Committee was instructed to prepare an abstract of the new law for the protection of birds, and to have a copy of the same mailed to each newspaper in the state. It was recommended that special attention be called to the fact that the English sparrow is not protected by law. J. T. Scovell spoke of the desirability of an effort being made to determine the height of Mt. Orizaba, Mexico, and of the advantages to be derived from such work being undertaken by running a line of levels from some determined point to the summit and definitely fixing each thousand foot mark as a reference point for biological investigations. The Academy voted approval of the plan as presented and agreed to assist in any way in its power should such plan be undertaken.

The next day was spent in exploring the lake and its shores, and was very much enjoyed. Boating, fishing, turtle hunting and collecting in many lines represented the various ways in which the members were employed.

In the evening the Academy met again at the Arlington Hotel. A

committee consisting of J. M. Coulter, P. S. Baker, A. J. Woolman, A. P. Carman and A. W. Butler was appointed to consider the relation that should be sustained by teachers in the High Schools to the Academy of Science. The natural characters of the region about Lake Maxinkuckee were then discussed until the close of the session.

Richmond was the place chosen for the "Field Meeting" of 1892. The kind and urgent invitation of the representatives of Earlham College made each one feel an assured welcome to Richmond and to Earlham. On the morning of May 12th the members met at the Arlington Hotel, and under the guidance of Professors Dennis and Moore proceeded to Thistlethwaite's Falls, above the city. The morning was agreeably spent along the several outcrops of the fossiliferous limestone. Before noon the party reached the college grounds. After examining the collections, dinner was served in the dormitory. In the afternoon, by the kindness of the people of Richmond, the members were driven in carriages to Elkhorn Falls, five miles down the Whitewater river. Upon their return they were driven about the city and given an opportunity to see its beauties, comforts and advantages.

Thursday evening the Academy met in Lindley Hall, Earlham College. President J. L. Campbell occupied the chair. J. M. Coulter spoke briefly of the objects and plan of the Academy. Dr. Alfred Springer then delivered an address upon "The Cell and Its Functions."

The thanks of the Academy were tendered Dr. Springer for his address.

The next morning the members visited the limestone outcrops below the city, going thence to the college where they again partook of dinner. Those who could remain spent the remainder of the day in the libraries, museums and laboratories. All regretted when leaving time came. The meeting was too short in time but was full of pleasures for which all will hold the Richmond friends in grateful remembrance.

AUTHOR LIST AND BIBLIOGRAPHY
OF
Papers Presented to the Academy

FROM 1885 TO 1891 INCLUSIVE.

Abbreviations explained on the page following the list.

ADAMS, B. F.

- '85. [See Van Nuys, T. C.]

ANDERSON, V. C.

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- '90. [See Stone, W. E.]
- LYONS, ROBERT E.
- '88. [See Van Nuys, T. C.]
- '90. [See Van Nuys, T. C.]
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- '90. An apparatus for determination of water in oils and fats.
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- '91. Plant zones of Arizona. [Pr. V.]
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- '86. A remarkable case of longevity in the longicorn beetle, *Eburia quadrigeminata*, Say.
- '86. The teaching of entomology in the high schools.
- '86. Descriptions of four new species of myriapods from the United States.
- '90. A list of the Orthoptera of Illinois, with descriptions of new species and observations on the songs and habits of little known species.
- MARTIN, G. W.
- '91. Organogeny of Aster and Solidago. [B. G., XVII, No. 11, and Am. N., XXVI, No. 311.]
- MARTIN, MISS LILLIE J.
- '86. Outline of a course in science study based on evolution.
- '87. A chemical study of *Juglans nigra*.
- '87. The value of organized work in plant chemistry.
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- '86. [See Branner, J. C.]
- MEEK, S. E.
- '86. *Elegatis pinnulatis* at the east end of Long Island Sound.
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- '88. Notes of the comparative value of several photometric methods.
- '88. Some curious phenomena in a four-plate Toeppler-Holtz machine.
- '88. Simple device for measuring the coefficient of expansion of solids.
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- '89. The use of two mirrors for the determination of the coefficient of expansion in solids.
- '89. Cause of periodicity in thermometers as discussed by Prof. W. A. Rodgers.
- '90. Description of a powerful electro-magnet with preliminary determination of its magnetic field.
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- '86. Recent progress in seismology.
- '88. Recent researches in atmospheric electricity. [Popular Address.]
- '90. The work of the United States Coast and Geodetic Survey. [President's Address.]

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- '87. The late drouth and its effect on vegetation.
- '87. Companion plants.
- '87. Notes on the white-spored agarics of Franklin county, Ind.

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- '91. Preliminary paper on the flora of Henry county, Ind. [Not yet pub.]

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- '85. Our knowledge of Indiana conchology.

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- '89. On the remains of a giant beaver found near Winchester, Indiana. [Not pub.]
- '90. A recent find of musk ox remains in Indiana. [Not pub.]
- '91. Variations in the dynamical conditions during the deposit of the rock beds at Richmond, Ind. [Not pub.]

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- '91. Hysteresis curves for mites and other cast irons.

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- '90. Circulation of sap.

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- '91. Recent archaeological discoveries in southern Ohio.
- '91. Methods observed in archaeological research.

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- '90. Notes on the apical growth of liverworts. [B. G., May, 1891.]
- '90. Notes on the germination of spores of *Notothylas*.
- '91. Notes on the development of the archegonium and fertilization in *Tsuga canadensis* and *Pinus sylvestris*. [B. G., May, 1892, and Pr. V.]

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- '85. The progress of physics in Indiana.
- '88. A new electrometer.

- '90. A set of resistance coils and Wheatstone's bridge.
 '91. An adjustment for the control magnet on a mirror galvanometer.
 '91. A combined Wheatstone's bridge and potentiometer.
- NEF, J. U.
 '87. On carboxylated derivatives of benzoquinone. [Journ. Lond. Chem. Soc., 1888, p. 428.]
 '87. On chloranil. [B. d. c. G., 1887, p. 2027.]
 '88. The constitution of the anilic acids. [Am. C. J., 1889, p. 17.]
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- NEWLIN, C. E.
 '90. Some new crustacean fossils.
- NEWSON, J. F.
 '90. A review of the Niagara group in Bartholomew county. Ind.
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- NOYES, W. A.
 '87. Beta-nitro-para-toluic acid. [Am. C. J., X, p. 472.]
 '88. On the atomic weight of oxygen. [Am. C. J., XI, p. 155.]
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- NOYES, W. A., and CHAS. WALKER.
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- NOYES, W. A., and W. B. WILEY.
 '88. On para-nitro-ortho-sulphamine-benzoic acid. [Am. C. J., XI, p. 161.]
- OSBORN, H. L.
 '86. Osphradium in Crepidula. [Am. M. M., Apl., 1887, p. 6.]
- OWEN, D. A.
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 '91. Strange development of stomata upon *Carya alba* caused by phylloxera. [Pr. V.]
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- OWEN, RICHARD.
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 '89. On sulphophenyl-propionic acid.
- PHILLIPS, A. E.
 '89. The portable water supply of the City of New York.
- PHINNEY, A. J.
 '86. Natural gas and petroleum.

- '86. *Loantharia rugosa*.
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 '88. [See Waters, E. G.]
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 '91. The contest against infection. [Cincinnati Lancet-Clinic, August 6, '92.]
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 '85. The progress of the study of mammalogy in Indiana.
 '86. Our blind mice.
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 '85. Meteorology in Indiana.
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 '87. Man an evolution — biological proofs. [Souvenir of Western Writers' Asso., 1890, pp. 173-184, and Pulpit and Pew.]
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 '89. [See Drew, Frank M.]
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 '86. The mildews of Indiana. [B. G., XI, pp. 60-63.]
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 '90. Distribution of Umbelliferae in North America. [Not yet pub.]
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 '89. Soap analysis. [J. of A. C., IV, p. 157.]
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 '85. Geographical studies in Indiana. [Not pub.]
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 '90. Sections of drift in Vigo county, Ind. [Not pub.]
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 '88. The epidermal cells of *Tillandsia*.
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 '91. On the occurrence of certain western plants near Columbus, Ohio. [Partially B. G., 1891, p. 155, and Pr. V.]
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 '86. The physical geography of Decatur county, Indiana, during the Niagara period. [Not pub.]

- '87. A list of the fishes of Decatur county, Ind. [Published privately. Apply to the author.]
- '87. List of butterflies of Decatur county, Ind. [Not pub.]
- '90. The occurrence of *Veratrum woodii* in Decatur county, Ind.
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- '91. Condensation of acetophenone with ketols by means of dilute potassium cyanide. [Pr. V.]
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- '89. A comparison of the life histories of different forms of plants.
- '89. The height of the atmosphere.
- '90. A refraction rainbow.
- '90. Geological section at Vincennes.
- '90. Preliminary list of Knox county plants.
- '90. Introduction of noxious weeds.
- STONE, W. E.
- '89. The carbohydrates of the sweet potato. [Ag. S., IV, p. 31 and B. d. c. G., XXIII, p. 1406.]
- '89. Specific reaction for the penta-glucoses. [Not pub.]
- '90. Notes on xylose. [Not pub.]
- '90. On qualitative and quantitative reactions for furfural. [Journal of Analytical and Applied Chem. V. No. 8, and B. d. c. G., XXIV, p. 3019.]
- '91. The digestibility of the pentose carbo-hydrates. [Am. C. J., XIV, No. 1 and B. d. c. G., XXV, p. 563.]
- '91. The action of phenyl-hydrazin on fufural. [Not pub. elsewhere.]
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- '88. [See Waters, E. G.]
- TAYLOR, F. B.
- '88. An objection to the contraction hypothesis as accounting for mountains.
- '88. The sun's light.
- '90. The highest old shoreline on Mackinac Island.
- '90. The effect of the Great Lakes on the ice sheet.
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- '88. A new kind of phosphorescent organ in *Porichthys*. [Bulletin Essex Institute, XXI, pp. 43-52.]
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- '91. An apparatus for determining the periodicity of root pressure. [B. G., 1892, p. 212, and Pr. V.]

- '91. The scales of Lepidoptera. [Not pub.]
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 '91. [See Moore, J. E.]
- TUDOR, JOSEPH H.**
 '90. Some features of the occurrence of *Viola pedata* var. *bicolor*. [Not pub.]
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- UNDERWOOD, L. M.**
 '91. The distribution of tropical ferns in peninsular Florida. Pr. V.]
 '91. Some additions to the state flora from Putnam county.
 '91. Connecting forms among the polyporoid fungi. [Zoe, III, pp. 91-95.]
- VAN NUYS, T. C.**
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 '91. Some suggestions to teachers of science or mathematics in high schools. [Pr. V.]
- VAN NUYS, T. C. and B. F. ADAMS.**
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 '87. The problem of the earthquake center. [P. A. A. A. S., 1888.]
 '88. A note on maxima and minima. [Not pub.]
 '89. Probable future of petroleum in southwest Indiana. [Indianapolis Journal.]
 '91. Some geometrical propositions.
 '91. Notes on numerical radices.
- WALKER, CHAS.**
 '86. [See Noyes, W. A.]
- WARDER, R. B.**
 '85. Chemical work in Indiana.
- WATERS, F. G. and J. B. PEDDLE.**
 '88. A new automatic repeater.

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- '86. Some biological studies of *Lixus macer*, Say, and *L. concavus*, LeC.
[Entomologica Americana, V, pp. 11-16.]
- '87. An unusual appearance of *Apatura celtis* along the St. Francis river, in Arkansas. [Insect Life, I, p. 29.]
- '87. Drouth, and its effect upon insect increase and decrease. [Not pub.]
- '87. Distribution of some species of injurious insects, throughout Indiana, during the season of 1887. [Not pub.]
- '87. The overflow of the Mississippi river and its effect upon the species of *Simulium* (buffalo gnats) infesting the smaller inland streams of the adjacent country. [U. S. Dep. Agr. Bureau An. Industry, 4th and 5th reports '87-'88, pp. 156-65.]
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- '91. Buffalo gnats (*Simulium*) in Indiana and Illinois. [Pr. V.]
- '91. Some insects of Tasmania. [Pr. V.]
- '91. Early published references to injurious insects. [Insect Life IV, pp. 262-5.]

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- '86. The scientific study of psychic phenomena. [Not pub.]
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- '88. The value of the refractive index in determining the adulterations of lard. [J. of A. C., II. Part 3 and Bulletin 13. Chm. Div. U. S. Dept. Agl. Part 4, p. 442.]
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- '87. The skull of *Necturus lateralis*.
- '88. Raphides in fruit of *Monstera deliciosa*.

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- '86. The nation -the subject matter of political science.

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- '89. Notes on Indiana butterflies. [Not pub.]
- '90. The fishes of the interior of Kentucky. [Bulletin U. S. Fish Com.]

ABBREVIATIONS IN THE PRECEDING AUTHORS' INDEX.

- A. N. Y. A. S.—Annals of the New York Academy of Sciences.
 Ag. S.—Agricultural Science.
 Am. C. J.—American Chemical Journal.
 Am. G.—American Geologist.
 Am. J. S.—American Journal of Science.
 Am. M. M.—American Monthly Microscopical Journal.
 Am. N.—American Naturalist.
 B. d. c. G.—Berichte der deutschen chem. Gesellschaft.
 B. G.—Botanical Gazette.
 B. I. E. S.—Bulletin Indiana Agl. Experiment Station.
 C. E.—Canadian Entomologist.
 I. F.—Indiana Farmer.
 J. C. S. of N. H.—Journal of the Cincinnati Society of Natural History.
 J. of A. C.—Journal of Analytical Chemistry.
 J. of M.—Journal of Morphology.
 N. A. J. of H.—North Amer. Journal of Homeopathy.
 O. & O.—Ornithologist and Oologist.
 P. A. A. A. S.—Proceedings of the American Association for the Advancement of Science.
 P. C. A. S.—Proceedings California Academy of Science.
 P. S. M.—Popular Science Monthly.
 Pr. U. S. N. M.—Proceedings U. S. National Museum.
 Pr. V.—Current volume of Proceedings of the Indiana Academy of Science.

ADDRESS BY THE PRESIDENT.

O. P. HAY, Butler University, Irvington, Ind.

A CONSIDERATION OF SOME THEORIES OF EVOLUTION.

We find in the physical history of the earth an illustration of evolution in the modern sense of the word, a progress in accordance with fixed laws from the simple to the complex, from the undifferentiated to the differentiated.

That philosophical minds should suspect that the world of organic beings, animals and plants, had been the subject of a similar course of evolution is not strange; and we find that such a suggestion has been often and long ago made. In modern times Lamarck has led the way; but neither were his theories adequate, nor were the men of his time ready to abandon their ancient conceptions. But when, in 1859, Darwin and Wallace published the results of their independently pursued studies and proposed a theory, definite and supported by a multitude of facts, their works attracted immediate and sustained attention. It is doubtful if any doctrine so subversive of universally accepted ideas has ever, in so short a time, received the recognition of so many of the educated and thoughtful minds of the world.

The doctrine of organic evolution, which attempts to explain the various differences and resemblances which exist among organic beings, depends on two laws, *heredity* and *variability*. The one law ordains that the living thing shall possess the essential characters of its parent or parents; the other law that it shall depart from those characters to a greater or less extent. Neither law can be questioned by anybody; only the extent to which the one law prevails over the other is in dispute. The evolutionists maintain that the law of variability may prevail over heredity to such an extent that after a greater or less number of generations, the deviations from the original form and structure may be so great that a new species may be produced.

In the attempt to explain how it is that new species originate, Darwin and Wallace hit upon the idea of "natural selection." In nature no two

individuals of a species are just alike. Each varies in some slight respect from the type. Of these variations, some may be indifferent, some useful, some harmful. According to these authors, these variations may affect all parts of the body, the form, the size and strength of single organs, color, or mental qualities. Again, all species tend to increase beyond the limits of space and food supply. From this latter cause there arises between the members of any species a struggle for existence. Moreover, all species are warred upon by many others, by which their food is appropriated and through which they themselves may be appropriated as food. In such a dire struggle it is, on the average, the best endowed individuals that will succeed in maintaining themselves and in producing offspring to inherit their useful characters; that is, the most vigorous individuals, those which have developed in the highest degree weapons of offense and defense, or protective colors, or the greatest cunning. The weakest, the most exposed, the most stupid, will perish and leave few or no young. From all the young produced by every species there is thus a constant and unsparing selection being made in favor of those individuals which can best endure the stress of the conditions. Hence the meaning of Darwin's phrase "natural selection," and of that used by Spencer, "survival of the fittest." Through the selection, for many generations, of the individuals possessing certain beneficial characters, these at length become fixed in the organization and strengthened until the organism is no longer what it was, but may have departed widely therefrom. Since success in the struggle is constantly demanding greater strength of limb and body, more efficient organs for each function, more weapons for assailing and repelling, more perfectly protective coloration, the general tendency of evolution has been upward; but the vigor with which the battle is waged may result in driving some species into such situations that degeneration may occur. Such are many burrowing animals and most parasites.

This process of natural selection is therefore quite similar to the artificial selection which is practiced by breeders in their effort to develop new varieties of animals and plants. Those individuals are selected which possess in the highest degree the desired quality; they are crossed with others having, if possible, the same quality, and the offspring of the pair are treated in the same manner, until the character sought is fully developed.

The rigorousness of the selective process that is going on in nature can

hardly be appreciated by one who has not given attention to the matter. To a casual observer, it may appear as if the most worthless individuals got a living, while the better perished. The well-favored do often succumb, and in ordinary times the weak may escape; but when periods of great food-scarcity, or of intense heat or cold, or of drought come, then the weak perish miserably. The eggs produced by some fishes reach into the millions. Could each one develop into an adult fish, which should in its turn give origin to an equal number of offspring, a very few years would suffice to fill all the seas with that fish. As it is, only perhaps one egg in a million becomes an adult fish. The least protected eggs are swallowed by enemies, the weakest young fishes die from disease and exposure, while only the most vigorous escape.

Our wild rabbits produce several young at a litter and a number of litters each year; yet the number of rabbits does not, on an average, increase. As many rabbits must therefore die each year as are born, and they seldom die of old age. Dogs and men, extreme cold and hunger, carry them off by thousands. Is there not here abundant opportunity for the development of swiftness of foot, acuteness of eye and ear, and of endurance?

As long as the environment remains about the same, little or no change may occur in the structure or specific characters of animals; but the whole organization is kept up to the highest grade of efficiency. Should there, however, be a gradual change in the conditions under which any animal is living, there would come about a corresponding change in the animal itself. Should there, for example, be developed a gradual increase in the speed of our dogs, there would, I doubt not, occur a corresponding improvement in the swiftness of our rabbits. I can see no reason for supposing that natural selection would not have the same effect here as man's selection does in the case of trotting horses.

Darwin's theory of natural selection was based almost entirely on observations made on domesticated animals and plants. Organisms in a state of nature did not seem to him to be subject to such frequent and extensive variations. We are only now beginning to appreciate how numerous and how important these variations are. They do not affect in only a slight degree a single organ of one individual in a decade or a century, but probably every organ of every individual, and to a very appreciable extent. The proverbial unlikeness of the individuals of every species is due to this variation. Wallace, in his "Darwinism" has given

us most impressive illustrations of this variation. Most of these illustrations have been drawn from the publications of our countryman, Dr. J. A. Allen, and relate to the winter birds of Florida. Allen made large collections and took accurate measurements of those portions of the body which are especially depended upon by naturalists in determining species, the length of body, wings, tail, tarsus, toes, and bill. All these parts were found to vary independently of one another, and the variations from the mean length often amounted to from 12 to 25 per cent. of the mean length. While, too, most of the parts measured were not far from the mean on each side, yet there were always a considerable number of individuals of each species that furnished measurements wide of the mean. The same principle is shown by Wallace to hold good among such lizards and mammals as have been studied. What is greatly needed is more extended observations among all classes of animals. I have examined some of our common snakes with reference to this matter of variation. We get the specific characters among snakes from the number of rows of scales across the back, the number broad plates along the abdomen and on the tail, and from the kind and arrangement of the colors. Anybody who has studied snakes has soon learned how extremely variable are their colors. Among specimens of the spreading adder, for example, may be found snakes of a plain gray or olive color without other markings, snakes with mere indications of blotches, snakes with most conspicuous spots of bright red or yellow and black, and snakes which are plain black. The other characters vary to a perplexing extent. What are merely individual, or at most, varietal peculiarities, have often furnished the basis for new species. In order to bring before you the range of the variations in important parts of these animals, I present the results of estimates which show how four species of our common snakes vary.*

These are the common garter snake (*Eutainia sialis*), the black snake (*Bascanion constrictor*), the smooth, green snake (*Cyclophis vernalis*), and the ring-necked snake (*Diadophis punctatus*.) From these it appears that in the number of the body vertebræ the garter snake varies from the average to the extent of 14 per cent., the black snake 6 per cent., the green snake only 4.5 per cent. and the ring-necked snake 13 per cent. In number of caudal vertebrae, the garter snake varies 35 per cent., the black snake 20

* The results here given have been deduced from the tables of measurements and counts of ventral and caudal plates given in Baird and Girard's "Serpeants of North America." Any considerable collection of the species above studied would furnish still greater deviations from the means.

per cent., the green snake 23 per cent., and the ring-necked snake 23.5 per cent. In proportion of tail to body the garter snake varies 9.4 per cent., the black snake 28 per cent., the green snake 25 per cent., and the ring-necked snake over 35 per cent. There is scarcely a doubt that every character in each of these species will be found to be as unstable as those which have been studied. And it must be observed, too, that each of the characters varies independently of the others, so that we may get any combination that we may want. If breeders should find it to their interests to raise a varied assortment of black snakes they could, doubtless, by careful selection and crossing, produce short-bodied snakes with long tails, long-bodied snakes with short tails, or snakes extremely short or very long in both parts. Much more might we expect that natural selection, which has more abundant materials to work upon and unlimited time, should be able to produce varieties and species to suit the requirements of the changing conditions of geological periods.

While the main proposition of Darwin and Wallace that species arise from earlier species by descent with modification, has been almost unanimously accepted by the scientific world, a number of scientific authorities have, within recent years expressed more or less dissatisfaction with the prominence that Darwin and Wallace and their followers have given to the doctrine of Natural Selection as an explanation of organic evolution. This dissent has expressed itself in degrees from questioning whether or not natural selection has been the only factor concerned, to open declarations that it has had little or nothing to do with evolution. Of course, those who deny the efficiency of selection to transform species endeavor to find some other principles or forces which, in their estimation, act as efficient causes, and thus we are beginning to witness the evolution of various schools of evolution. And here it seems proper, as a matter of justice to Darwin, to deny that he, at least in his later works, maintained that natural selection is the only influence at work to bring about changes in organisms. One cannot read his works with even moderate attention without recognizing that he admitted the operation of the very forces and principles that many of these later evolutionists rely on to explain the phenomena of organic change. Only Darwin did not assign the same high value to these factors that some authors do now. Wallace, on the other hand, in his latest work advocates the earlier position of Darwin, and stands for what he calls the "overwhelming importance of Natural Selection over all other agencies in the production of new species."

Now, it matters not the degree of importance that we give to Natural Selection as a principle in organic evolution, it does not appear that we can regard it as furnishing a final solution of the phenomena to be explained. This objection has been justly urged: Natural selection acts only on characters which have been already produced and have become either useful or hurtful. By what means have they been produced? Before they can be selected they must exist; what principles or forces gave them their existence? It has been urged that if there are influences that can bring characters up to the stage where selection can begin to act on them, the same influences might continue to perfect them. Darwin saw the situation clearly. He says, in his "Descent of Man:" "With respect to the causes of variability, we are in all cases very ignorant, but we can see that in man, as in the lower animals, they stand in some relation with the conditions to which each species has been exposed during several generations." He then mentions, as some of the probable causes of change, the direct and definite action of changed conditions, the effects of increased use and disuse of parts, arrests of development, correlated variations, &c. Under such circumstances it becomes a legitimate subject of inquiry what those forces and conditions are which have been active in initiating changes in organisms, and what effect, if any, Natural Selection has had in perpetuating and accumulating these new characters and of repressing others.

One of the most recent and most thoroughly elaborated attempts to account for the variations of organisms is that of Dr. Aug. Weismann. It is presented in a series of lectures delivered between the years 1880 and 1890. The fundamental idea of his theory he has denominated "*the continuity of the germ-plasm*." All except the lowest animals are produced from eggs, which are essentially cells. When the egg is fertilized, it develops into an embryo by a process of division which leads to the production of an immense number of cells. These, becoming more and more differentiated in definite ways, form the tissues and organs of the adult being. Thus, from a simple egg there arises an animal which inherits the general features of the parent and even many of its minor peculiarities of form and habits. At some time during embryonic development there are separated from the other cells of the organism certain cells which in due season develop into eggs, as a provision for the continuation of the species. It appears hitherto to have been assumed that the materials of these eggs, or germ-cells, is derived by some process of trans-

formation from that composing the ordinary, but not yet greatly modified, cells of the body. Dr. Weismann, on the other hand, maintains that the egg, or more exactly the nucleus of the egg, contains a substance, his *germ-plasm*, which possesses a peculiar chemical, and more especially molecular, structure, and which is the bearer of "the whole of the inherited tendencies of development." In the process of the development of the embryo, not all of this germ plasm is consumed in the construction of the body; but a small portion is set aside and remains in the body of the embryo unchanged, and destined to enter at the end into the formation of the eggs which shall give being to the next generation. The materials of the body cells Weismann calls *somatoplasm*, to distinguish it from the germ-plasm. The germ-plasm, although borne about in the body of the organism that in time will produce offspring, and though nourished by its somatoplasm, is wholly distinct from the latter, and is very slightly if at all affected by it. Weismann says of it: "The germ-plasm, or idioplasm of the germ-cell, certainly possesses an exceedingly complex minute structure, but it is nevertheless a substance of extreme stability, for it absorbs nourishment and grows enormously without the least change in its complex molecular structure." Weismann even maintains that this reproduction of the germ plasm without change may go on for thousands of years. He has compared the germ-plasm to a creeping rootstock which at intervals sends up a vigorous shoot. The shoot flourishes for awhile and dies, but the rootstock survives, to produce other shoots in indefinite number. The germ-plasm enjoys a sort of immortality.

The cause of heredity has always been a mystery. How is it that a cell which has not the slightest resemblance to the animal that produced it can go through a complicated series of divisions and transformations and at last gradually, but unerringly, reproduce even to minute details the structure and form of the parent? How is it that two eggs, indistinguishable from each other, but laid by different animals, developing perhaps under identical circumstances, can reproduce exact copies of their respective parents? Darwin attempted to give an explanation by assuming that each cell of any organism emits minute particles, called by him *gemmules*, which enter the germ-cells and become there representatives of the cells of the whole body. The germ-cells must according to this theory contain millions of gemmules. When development of the egg occurs the contained gemmules determine the reproduction of their respective cells in due order of time, place, and form. When any part of the body

of the parent has undergone variation, this will be represented in the egg by the gemmules of the part and may thereby be inherited. The immense number of gemmules required to effect the results, as well as the lack of sufficient evidence of a positive kind in favor of Darwin's theory, have prevented its general acceptance.

On Weismann's theory, heredity follows from the assumption that both parent and offspring are derived from the same mass of germ-plasm. That which had given origin to the parent must be expected to develop into a similar organism in the offspring. That the germ-plasm develops into the peculiar structure and form of both is due to its molecular structure, the result of gradual modifications which have been accumulating during the ages that have elapsed since their earliest ancestor received its being.

Some extremely important conclusions issue from the acceptance of this theory of Weismann's. If the germ-plasm, borne about in the body of any organism, protected and nourished by it, does not have its molecular constitution, on which the character of the offspring depends, at all affected by the state of the parent's body then none of what are called acquired characters can be transmitted from one generation to another. This fact, if fact it be, strikes at the very root of other promising theories. Then none of the results of the use and disuse of organs will be transmitted; none of the direct effects of the climate or soil, or any of the environment on the body of the parent, will show in the descendants; nor will any mutilations be inherited. The heat or the cold, the drought or the flood, may produce the most profound effects on the animal or the plant, in the way of altering its form or structure or color, but the offspring will not directly inherit any of these results.

Since, however, Weismann firmly believes that existing species have been derived from older species by descent and modification, how does he account for the variations that must have arisen? This is done on the theory of *sexual mixture*. The germ-plasm of every individual of every species has certain peculiarities, which are passed on, with greater or less intensity, to the next generation. The male animal or plant has certain hereditary tendencies, that of the female different tendencies. When the germ-cells of the two individuals have united, an organism develops that is different in some respects from both the parents, being, as Weismann expresses it, a compromise between the two developmental tendencies. Since the numbers of individuals of every species are numerous and no

two are alike, new combinations of the germ-plasm are continually arising, and these express themselves in still other individuals which are different from any that have ever lived. Amid all these variations, which indeed will affect every organ, are some which are hurtful to the organism, and others which are advantageous. Such variations will come under the influence of natural selection, the individuals possessing hurtful variations being destroyed, those with advantageous variations being preserved and made the means of transmitting on to future generations the improvement. Organic evolution, then, according to Weismann, depends on two factors, variation brought about by sexual mixture, and natural selection. Indeed, according to him, the production of variations that may be inherited constitutes the whole significance of sex; it is simply a device of nature for the origination of variations through which natural selection may effect improvement. As a corollary from this proposition Weismann deduces the conclusion that any organisms which do not reproduce sexually, such as certain parthenogenetic insects and crustaceans, cannot undergo variation; and should their environment change to any considerable degree they must perish. However, since the publication of his lectures, Weismann has been compelled to recede from this position.

But if it be true that external influences have had nothing directly to do in bringing about inheritable changes in organisms, and if the species of one age have descended from more ancient species, how did the hereditary individual differences arise in the beginning? With most other evolutionists he believes that the Metazoa have been derived from the Protozoa. In the Protozoa, there is no reproduction by means of eggs. The animal is at once parent and egg. When reproduction occurs, it is usually accomplished by the division of the animal into two portions of equal size and similar form, so that it is impossible to say that either is parent or offspring. Each part reproduces in a similar way; and since there appears to be no reason why, in case the environment remains favorable, any of the products of division should ever die, Weismann regards them all as having potential immortality.

It must be remembered now that Weismann admits that external forces and conditions, as well as the use and disuse of organs, may affect profoundly the organization of even the higher animals, although he denies that any of the direct effects will be passed on the next generation. In like manner the *Protozoon* is influenced by external conditions and would

have changes wrought in its body. Now since its *body* is at the same time the *reproductive element*, whatever modifications have arisen in the body would be inherited by the two portions into which it would divide. "If," says Weismann, "a Protozoon, by constantly struggling against the mechanical influence of currents in water, were to gain a somewhat denser and more resistant protoplasm, or were to acquire the power of adhering more strongly than the other individuals of his species, the peculiarity in question would be directly continued on into its two descendants, for the latter are at first nothing more than the two halves of the former." By the time, therefore, that some of the Protozoa, through more and more intimate association into colonies, by differentiations of the cells for the performance of different functions, and the production of germ-cells as distinguished from the body-cells, became modified into the primitive Metazoa, those individual differences had arisen which, constantly multiplied ever since by sexual mixture, have furnished the materials on which Natural Selection has worked to produce all the living animal forms that now exist.

It must be understood that, as regards the reproductive elements of the higher animals, Weismann contends for the continuity of the *germ-plasm*, not for that of the *germ-cells*. Embryology proves that the latter cannot be maintained. As Weismann says, "continuity of the germ-cells does not now take place, except in very rare instances." In certain insects there are, at the very beginning of development, a few cells separated from the others and afterwards received into the body of the embryo, in order later to develop into eggs. In some crustaceans, the germ-cells become distinct when about thirty cells have been produced. In vertebrates they do not usually become distinct from those composing the body until the embryo has been completely formed. Among the Hydroids, reproduction occurs largely by budding. The buds may develop into independent bodies, jelly fishes, which swimming away and attaining a large size, give origin to the germ cells. These do not make their appearance until after hundreds and thousands of cell-generations have been passed through. They arise originally from certain cells of the ectoderm, but make long migrations to the places where they finally undergo development into perfect eggs. Among plants, a fertilized ovule gives origin to an embryo. This may develop into a large tree, which finally will, at the tips of branches a hundred feet away, produce new ovules. Through millions of cells the germ-plasm must have made its way to reach those

terminal buds. And the cells must contain this precious substance without showing its presence. Weismann says, "It is therefore clear that all the cells of the embryo must for a long time function as somatic cells; and none of them can be reserved as germ-cells and nothing else." How then does he explain the transference, through such long distances, of the germ-plasm? Referring to the Hydroids he says: "I concluded that the germ-plasm is present in a very finely divided and therefore invisible state in certain somatic cells from the very beginning of embryonic development, and that it is transmitted through innumerable cell-generations to those remote individuals of the colony in which the sexual products are formed."

But this transportation of the germ-plasm through so many generations of cells is by no means the only difficulty that besets Weismann's theory. There is a number of plants, among them the begonia, which may be propagated from pieces of the leaves. It would almost appear as if single cells of the leaf would reproduce the plant perfectly. Among the ferns it is no uncommon thing for new plants to spring from the surface of the leaves or of the stalks. Among mosses almost any cell of the root-hairs will develop into new plants. As pointed out by Strassburger, the germ-plasm must, in these cases, not merely travel through the plant to the *reproductive organs*, but be widely diffused throughout every part of the plant, and Weismann admits that this is the case. Similar phenomena occur among animals. If the fresh water *Hydra* is divided into two pieces, each will develop into a perfect *Hydra*. Trembly, in his experiments on these things, minced some of them into as small pieces as he could, and almost every piece developed into a perfect animal. It is stated that as many as forty were thus reproduced from a single one. When certain worms are cut in two, each part develops into a perfect individual. All animals show some power of reproducing lost and injured parts. How shall we explain these facts of reproduction and restoration? Is the restoration of the hydra due to the presence of germ-plasm or not? If it is claimed that it is due to the germ-plasm, it may be replied that it has not reproduced the animal, but only a part, that part which was missing, it may be the half of it or the greater part of it. When the worm is cut in two one cut surface may develop a new tail, the other surface a new head. Had the cut been made the thickness of a cell further forward, those cells that in the first case engaged in developing a new head would probably as readily have gone to work to produce a new tail. Does germ-

plasm possess the power of reproducing the whole animal, or the head end or the tail end, according to circumstances? If the germ-plasm is concerned in these restorations of parts, we can hardly exclude it from other cases of restorations, and this will lead us to the admission that germ-plasm is present in nearly all the tissues of all animals. If the position is taken that the germ-plasm is not concerned in the cases that have been referred to, but some degraded product of germ-plasm, then we may say that such materials have powers curiously similar to those of germ-plasm itself, but even more wonderful. To what extent is the material of the cells of the cut surface of the worm different from that of germ-plasm itself, when those cells have the inherited power to produce either head or tail as demanded by the needs of the worm? If the molecular structure of germ-cells and of body-cells is so similar, is it impossible that some of the body-cells may undergo retransformation into germ-cells? Furthermore, whether this suppositious reproductive material is or is not concerned in the restoration of the minced hydra it must, if it exists at all, be present in all the cells. For, so far as we may judge, each hydra that has grown from a minute bit of hydra is capable of giving origin, when divided, to many new hydras, and these to others indefinitely. Since the last of such a series would, without doubt, be able to produce eggs the germ-plasm must have been contained in all the cells of all the series.

Weismann's conception is that the highly organized germ-plasm found in the nucleus is, after the first division, no longer what it was before, except that part which has been reserved,—is indeed no longer germ-plasm at all. At each subsequent division its structure becomes simpler as it gives origin to more and more complex tissues; that is, its energy runs down as it does work in forming tissues. He claims that, when the germ-plasm has thus become simplified, its character as germ-plasm can never be restored. It might be supposed that, if we could find any cells which, having once formed a part of any body-tissue, should take upon itself the powers of a reproductive cell, Weismann's theory would stand disproved. We then direct attention to the somatic cells of hydroids which develop into eggs. But Weismann accounts for this by supposing that the germ-plasm enters the cells and takes the place of the germ-plasm.

However, it appears to me that it must be admitted that the germ-plasm is so widely diffused through the tissues of many, if not all, organisms, and is so much like the substance of many other cells in its reproductive powers, as to make it doubtful whether there is any such dis-

tinct material. We may not be able to prove that it does not exist, but we may do as we do with other ghosts, prove the superfluousness of its existence. It is indeed a wonderful property that is possessed by the germ-cells of the animal, that of reproducing the form, organs, tissues, and millions of cells of the parent; but the cells that can reproduce the severed head of any animal, with its many sense organs, appear to me to possess a property even more wonderful. For the germ-cell has a structure and corresponding capacities which are the ingrained results of countless repetitions of the act of reproduction, while nothing of this kind can be said with regard to the cells which reproduce the head, or the tail, or the foot. It looks as if every cell of the whole body were originally endowed with the capability of reproducing all the others in due order; as if, indeed, something like Darwin's theory of pangenesis were really true. Through subsequent high differentiation of structure, or through unfavorable surroundings, the cells may not be able to accomplish the restoration, but they show that they possess at least a memory of their old duties.

In his last essay, that which treats of the transmission of acquired characters, Weismann reasserts strongly their non-transmissibility, be they produced in any way whatever. At the same time, he seems to me to introduce a new explanation of variation, and to make admissions which may prove fatal to his theory. It must be recollected that Weismann has been contending for the stability of the germ-plasm; that, in order to account for the variations that individuals show, he has invoked the agency of sexual mixture, which he regards as an invention of nature for that special purpose; that he has claimed that animals reproducing by parthenogenesis can undergo no adaptive changes. When speaking of the effect of external influences he says: "Without altogether denying that such influences may directly modify the germ-cells, I nevertheless believe that they have no share in the production of hereditary individual differences." He has just previously maintained that the transformation of a species can take place only through the accumulation of these individual differences. Now in the last essay, in discussing certain objections which have been urged against his doctrines, he contends that external conditions, light, heat, moisture, nutrition, and their opposites, can produce great changes in the body, but none directly in the germ-plasm. He grants, however, that the environment may act *indirectly* on the germ-plasm, so as to bring about important changes in the characters

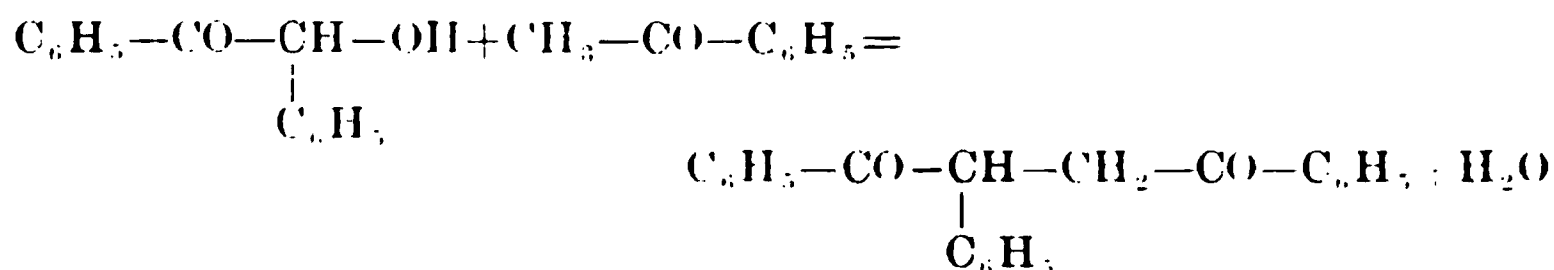
of animals and plants. He declares that he has never doubted the transmission of changes which depend on alterations of the germ-plasm. He then inquires: "And how could the germ-plasm *be changed* except by the operation of external influences, using the words in their widest sense?" To this we may reply, that he has hitherto attributed all changes to sexual mixture alone. If he is willing to admit that use and disuse of organs, changes in nutrition, and in the environment in general, may bring about modifications of organisms, he will not find it difficult to come to an agreement with many of his opponents, even if he does insist on postponing the results for a few generations. A few may insist that some characters acquired by the parent, for instance by the use of an organ, may be inherited by the next generation, but most persons would contend only that a predisposition to the reproduction of the character is inherited.

PAPERS READ.

CONDENSATION OF ACETOPHENONE WITH KETOLS BY MEANS OF DILUTE POTASSIUM CYANIDE. By ALEX. SMITH.

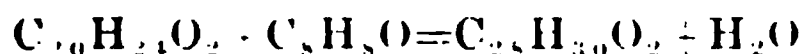
[ABSTRACT.]

It has been proven for some years that when benzaldehyde is boiled in dilute alcohol with a small quantity of potassium cyanide, two molecules of benzaldehyde unite to form benzoin. The present paper describes a class of cases where the same reagent has the power of causing the union of two bodies with the elimination of water—a condensation. The interaction takes place between a ketol such as benzoin, on the one hand and a ketone such as acetophenone on the other. For example benzoin and acetophenone in dilute alcoholic solution, in presence of a little potassium cyanide, yield on boiling desyl-acetophenone. (Jour. Chem. Soc. LVII, p. 643.)



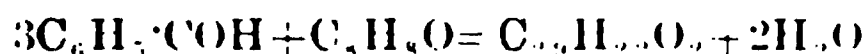
The interaction is now found to extend to other ketols. From cuminoïn

and acetophenone, cumino-desylacetophenone was prepared according to the equation—



It is a substance melting at 145° C. With phenyl hydrazine it yields an o-diazine derivative and its constitution as a 1:4 diketone was proved by its yielding furfurane and pyrrol derivatives. Piperonoin, furoin, and benzoylcarbinol have also been used, and the interaction seems to hold for them also. The products have not yet been fully investigated.

In all cases a small amount of another, much less soluble, product is formed. The equation for this action seems in the case of benzoin to be—



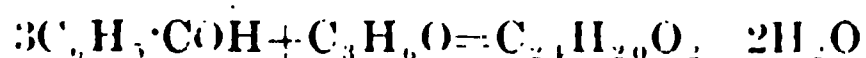
The examination of these products is in progress.

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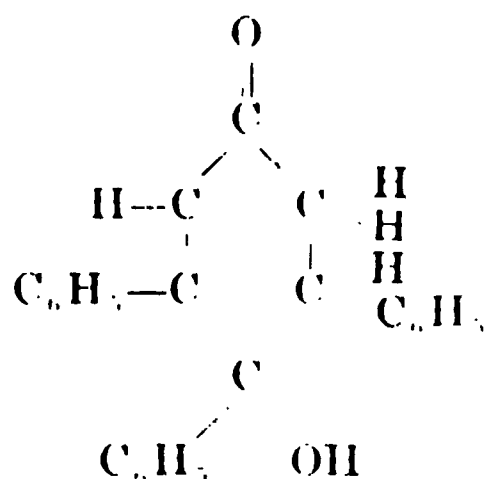
CONDENSATION OF ACETONE WITH BENZOIN BY MEANS OF DILUTE POTASSIUM CYANIDE. By ALEX. SMITH.

[ABSTRACT.]

In connection with the work mentioned in the preceding paper, experiments were also made where the ketol was benzoin but acetone was used in place of acetophenone. The main course of the interaction was an entirely different one. A substance melting at 246° C was produced according to the equation—



It appears to possess the following constitution:



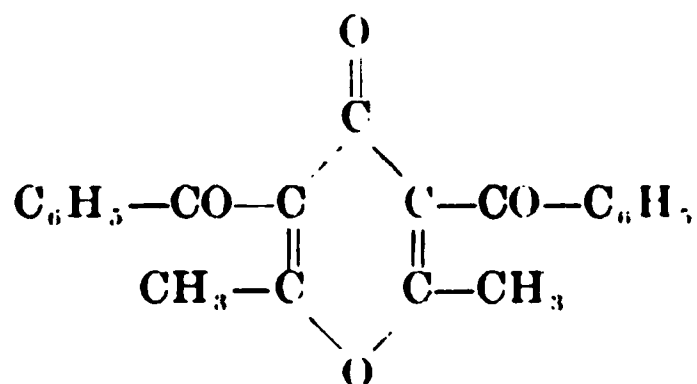
It yields a monoxim and a monophenyl hydrazone. With acetic anhydride it yields the acetate of triphenyl phenol. From this triphenyl phenol itself is obtained by saponification. Distillation over zinc dust yields the hydrocarbon triphenyl benzene and the original substance yields the same

product under similar treatment. A substance, found to have almost identical properties, is described by Japp (Chem. Soc. Jour., vol. LVII, p. 783). He had formerly ascribed to it the formula $C_{46}H_{40}O_4$. In the later note he points out that the analysis agrees approximately with the formula $C_{24}H_{20}O_2$. The substance was prepared by Japp's method, namely the action of dilute caustic potash on a mixture of benzoin and acetone in alcoholic solution. It appears to be the same body as that obtained by the action of potassium cyanide, but acetic anhydride acts on it with extreme difficulty only and distillation over zinc dust yields none of the hydrocarbon.

PYRONE AND PYRIDONE DERIVATIVES FROM BENZOYL ACETONE. By ALEX. SMITH.

[ABSTRACT.]

Conrad and Guthzeit's reaction was applied to benzoyl acetone. Cuprobenzoyl acetone was found to yield with phosgene a pyrone derivative possessing the formula—



Dimethyldi-benzoyl pyrone melts at 188°C . With phenyl hydrazine it yields a diphenyl hydrazone and with ammonia the oxygen of the ring is replaced by the group :NH and dibenzoyl-lutidone is formed. Similarly the action of aniline gives dibenzoylphenyl-lutidone. These substances are bases whose hydro-chlorides form double salts with platinum tetrachloride.

CARBON DIOXIDE IN THE URINE. By T. C. VAN NUYS and R. E. LYONS.

From the intense alkalinity of the normal urates, as well as the di and basic phosphates of potassium and sodium, we were led to believe that, ordinarily the urine is not alkaline from the presence of the carbonates of

the alkali metals; that in all probability CO_2 is not in combination in normal or moderately alkaline urine.

To determine this, the CO_2 in the total urine of 24 hours was estimated after employing, (1) mixed diet, (2) vegetable diet, (3) after injecting large doses of neutral tartrate of sodium.

(1). Mixed diet—Urine acid in reaction.

First day . . . 0.64 gram. CO_2 .	Fourth day . . 0.56 gram. CO_2 .
Second day . . 0.49 " "	Fifth day . . . 0.45 " "
Third day . . . 0.60 " "	Sixth day . . . 0.79 " "
Average for each day, 0.588 gram. CO_2 .	

(2). Vegetable diet—Urine strongly alkaline, but did not effervesce on the addition of an acid.

First day 1.20 gram. CO_2 .	} Average for each day, 1.09 gram. CO_2 .
Second day 1.16 " "	
Third day 0.93 " "	

(3). After injecting neutral tartrate of sodium urine became alkaline, which was in part due to carbonates, as the urine effervesced *slightly* on the addition of acid.

First period 48 hours following "mixed diet":	Gram. $\text{C}_4\text{H}_4\text{Na}_2\text{O}_6$ taken in 24 hours:	Gram. CO_2 in the urine of 24 hours:
First day	10	1.42
Second day	10	1.65
Second period 48 hours following "vegetable diet":		
First day	15	1.30
Second day	15-17	2.67

From our investigations we conclude:

1. Combined CO_2 is not ordinarily a constituent of normal urine.
2. When CO_2 does appear in combination, it is owing to the excessive alkalinity of the blood when it combines with the hydrates of potassium and sodium.
3. Alkalinity of normal urine, unless excessive in degree, is caused by di- or tri-basic phosphates, and normal urates of potassium and sodium.

RESULTS OF ESTIMATION OF CHLORINE IN MINERAL WATERS BY VOLHARD'S PLAN. By SHERMAN DAVIS.

In "Die Untersuchung des Wassers," by Drs. Tierman and Gärtner, page 132, we find directions for the estimation of chlorine in mineral waters. The method given is essentially that of Volhard. It is the object of this

paper to call attention to two points in this process: First, though it has been remarked by previous observers that there is a reaction between the *silver chloride* formed and the ammonium sulphocyanide, is not this reaction sufficient to produce an appreciable error? We here give some observations made, with this point in view.

WITH DISTILLED WATER.

No.	Time	Filtered.	$\frac{1}{10}$ N. Na Cl.	$\frac{1}{10}$ N. Ag. NO ₃	$\frac{1}{10}$ N Am. Sulph.	Ferric Alum.	HNO ₃ (1.2)
	Min.						
1 . .	5	no	4	1.62	3	3	3
2 . .	5	"	"	5½	1.85	"	"
3 . .	3	"	"	"	1.70	"	"
4 . .	2	"	"	"	1.70	"	"
5 . .	3	"	"	"	1.75	"	"
6 . .	2	"	"	"	1.65	"	"
7 . .	1½	"	"	"	1.70	"	"
8 . .	2	"	"	"	1.80	"	"

These data seem to indicate that even though the time be reduced to a minimum, the results are inconsistent and misleading. Now these variations may be eliminated by a process of *filtering*. Introduce a quantity of sodium chloride, say 4cc from a $\frac{1}{10}$ normal solution, into a 200cc graduated flask, add 4cc nitric acid (1.2 sp. gr.), free from *nitrous acid*, and with distilled water at 15° C fill to mark. Mix well. When the silver chloride has been separated, filter off 100cc of the fluid through a *dry filter*. Introduce the filtrate into a titrating flask, add 2—3cc sat. sol. ferric alum and titrate with the $\frac{1}{10}$ nor. sol. am. sulphocyanide, till the addition of one drop causes a light brown color to appear. This color once produced will be permanent. The results of such a device are shown by the following data:

No.	Time	Filtered.	$\frac{1}{10}$ N Na Cl.	$\frac{1}{10}$ N Ag. NO ₃	$\frac{1}{10}$ N Am. Sulph.	Ferric Alum.	HNO ₃ (1.2)
1	yes	4cc	7cc	1.55	3	3
2	"	"	"	1.50	"	"
3	"	"	"	"	"	"
4	"	"	"	"	"	"
5	"	"	"	"	"	"
6	"	"	"	"	"	"
7	"	"	"	"	"	"
8	"	"	"	"	"	"

These results agree with the quantities introduced and are constant. This device was employed in estimating the chlorine in the waters from West

Baden. French Lick, Mt. Aris, Indian and Trinity Springs. The results were *constant and accurate*. It also holds in waters containing much mineral matter and organic matter to 350 parts in 100,000.

Second. Will there, without filtering, be an appreciable error? We produce the following data:

WITH DISTILLED WATER.

No.	Time.	$\frac{1}{10}$ N Na Cl.	$\frac{1}{10}$ N Ag. NO ₃	$\frac{1}{10}$ Am. Sulph.	Ferric Alum	HNO ₃ (1.2)
1 . . .	1	3cc	3.5cc	.78cc	3	3
2 . . .	5	5	3.5	.75	"	"
3 . . .	10	3	3.5	.75	"	"
4 . . .	12	"	"	.82	"	"
5 . . .	10	"	"	.75	"	"
6 . . .	10	6	6.5	1.00	"	"
7 . . .	10	6	6.5	.88	"	"
8 . . .	10	"	"	1.00	"	"

We differed from the authors in this—that the solution was *gently* agitated until the color no longer disappeared. With such a standard the error may reach 1.77 pts. in 100,000 pts. as shown by the eighth titration. The observations justify the following inferences:

First. There is an appreciable reaction between the silver chloride and the ammonium sulphocyanide.

Second. The error varies directly with the quantity of chlorine present, and the time employed.

Third. When the reaction of chlorine upon silver nitrate is effected in the presence of ammonium sulphocyanide, the results are inconstant.

Fourth. That it is necessary to filter off the silver chloride, before adding the ferric salt.

Fifth. That by filtering the results are *very* accurate.

Sixth. That if the solution, unfiltered, be allowed to stand ten minutes, the reactions which take place, will produce very appreciable errors.

SOME SUGGESTIONS TO TEACHERS OF SCIENCE OR MATHEMATICS IN HIGH SCHOOLS.

By THOS. C. VAN NUYS.

It is the purpose of the writer to endeavor to indicate, as briefly as practicable, the spirit which should influence teachers of science or mathematics in high schools.

It is needless to state in this connection that the spirit, in which a teacher

performs his duty, arises from his conception of what education is, consequently, correct views of education in general, are of very great importance to teachers. No system of education can exist, without grave defects, unless there is in the system a certain degree of uniformity in the curriculum of study. Classes of studies for periods of time should be so grouped, that by the pursuit of them, the pupil is led to the highest degree of discipline and culture. Fortunately, the course of study in the public schools of this country is pretty well formulated, but, unfortunately, the course is better adapted for preparing pupils for technical or business education than for scholarship or the learned professions. This defect, however, may, in part, be remedied by the efficiency of teachers.

In order that the teacher of elementary science or mathematics in a high school may become proficient in his work he should first determine what benefit are the pupils to derive from a course of instruction in mathematics and elementary science. Notwithstanding, the tendency of the age is in favor of technical education, the fact is, no class of studies can take the place of the inflected languages, history and literature for a high degree of discipline and culture, and, that full benefit should be derived from linguistic studies, they should be introduced, early in the course, as training in them is easier at an early age.

The study of the humanities, if pursued early in life, when the emotional faculties are springing into existence, results in refining, cultivating the tastes and engendering a broad philanthropy. This is readily understood when it is taken into consideration that through the study of the ancient languages, the pupil becomes acquainted with different phases of human thought, and, because different from modern thought, they are not the less human.

With thorough training in these studies, early in life, the pupil becomes disciplined and refined, disciplined, by long continued mental drill, necessary in acquiring knowledge of the inflected languages, and refined, by sympathy for mankind acquired by a knowledge of the vicissitudes through which the human race has passed. This comes from the study of the humanities being subjective as well as objective. On the other hand, the study of science and mathematics is objective. In these pursuits, the emotions may be dormant, while reason is called into activity. If this be true, it is readily understood why the study of languages, history and literature should precede the study of the sciences and higher mathematics.

To reach the highest results in education the tastes, the moral faculties

and the sensibilities should be developed as well as the intellectual; otherwise, the development is not symmetrical.

The teacher should not encourage the popular opinion that the education which does not enable a person to superintend a factory, make shoes, or build a bridge, is worthless.

In this materialistic age we are apt to employ our educational forces so as to intensify the mad strife we have about us, to make prominent those studies, by a knowledge of which, wealth is acquired and to neglect those studies which tend to refine, temper and balance the mind.

The word discipline is perhaps the most difficult term in pedagogical science to define. No attempt will be made to offer a definition here, further than to state, that by discipline, the pupil has power of self-control, that by it, undivided attention can be concentrated to the subject under consideration. By discipline, there is economy in mental work. The mind is disciplined when it possesses the art of thinking. To many it would seem absurd that it requires many years of systematic study, under good instruction to read a book, or study a subject with profit and, therefore, with understanding, and yet, it is true. While it is claimed that the study of the inflected languages, history and literature, pursued early in life, is imperative for discipline, culture and scholarship, yet if the study of higher mathematics and science be not subsequently pursued (and it might be added in proper spirit), the work of preparation is incomplete.

It is a recognized fact that the body soon becomes accustomed to certain movements which are, with sufficient practice, made almost unconsciously, so the mind, with practice, soon becomes accustomed to certain processes of reasoning.

Although the study of the humanities presents many aspects of thought, yet the mind of the classical student runs in grooves. For him the study of higher mathematics opens up a new field of thought as the processes of reasoning are essentially different from those employed in the study of the humanities.

Method and system in the processes of reasoning are characteristic of the mathematical mind.

The study of chemistry is of importance as a means of cultivation of the powers of observation, but, perhaps, the greatest value of the study of chemistry, is the knowledge of the constitution of matter and the changes it undergoes, producing new bodies. The cultured pupil reads here a wonderful story. His mind dwells on the growth and consequent changes of

living languages, so rapid are these changes that a language is scarcely the same each decade. Every period of history is stamped with changes. Nations grow like plants, remain in the developed state a time, then they decline and upon their ruins other nations spring up, likewise to perish. The student reads in chemical science a similar story told in symbolic language. Hitherto he knew but little of the laws of matter, he now learns that matter and its laws form the basis of all. Were it not for the facts on which the atomic theory is based and were it not that forces are evolved by the reduction of organic matter there could be no mental process, in fact no brain, no muscle. Now, while this expresses a phase of materialistic philosophy yet the pupil who has a thorough training in the studies of the humanities is not easily thrown off his balance. By his long continued training he recognizes the fact that the moral sense or sentiment is a potent factor in nature, that man is not a selfish animal seeking to survive that he may enjoy his sensuous pleasures. Although the age is becoming more rationalistic, yet there never was a time when society was subject to so much vacillation, frivolity and extremes. The craze for something new or sensational precludes sober thought. We may as a nation excel all others in inventions and conveniences and yet we may become a nation of artisans and tradesmen. The pupil who is educated in the humanities, and therefore has a disciplined mind, does not seek for wild theories, even if founded on the results of modern research. Too many men, who represent the results of the new education are without convictions. The character of too many is reflected by current of popular opinion. The greatest need of this age is a generation of men, cultured and disciplined, who have convictions and therefore are not moved by the great waves of thought which often sweep over the country like an epidemic.

The teacher of science, or higher mathematics, in a preparatory school, should consider himself employed to build over, or bridge a chasm at the end of a long line. He should consider his work a necessity to fill out, and round up the intellectual and moral character of the pupils, under his charge.

However different his work may appear from the work of his colleague who teaches the Greek language, or his colleague who studies, with his classes, Shakspeare, Dante or Milton, his work is along the same line. The teacher of science will benefit his pupils much more by confining his instruction to general principles, whether he teaches elementary chemistry, botany or zoology.

After having spent years of persistent study of languages, literature and history, acquiring a knowledge of the inflections of verbs, memorizing the definition of words and becoming familiar with the outline of all forms of speech, with the political divisions of countries of the remote past—in short, with the life of a world in its childhood and now to be introduced into the world of the present, constitutes the most interesting period in the life of the pupil. The teacher guides with watchful care the mental processes awakened by the study of nature. He witnesses a wonderful mental development, wonderful because it springs from a rich store-house of knowledge and because the mental processes are new.

After all, the ultimate object of education is utilitarian in character. The educated man or woman, who is a useful member of society, who is of value to the state, must be of the world. He must be brought in intimate relationship with the affairs of the present, and, for this purpose, the study of science and mathematics is well adapted. A full degree of utilitarianism is not wholly technical in kind. To become useful in any of the learned professions all of the discipline afforded by classical and scientific training, in addition to the training in the professional studies proper, is required.

If education is to be the safeguard of the nation, if it is to prevent the enactment of extreme measures, if it is to act as the balance wheel in the machinery of the social state, it must result in the development of all the resources of the intellect as well as the sense of justice and love of humanity.

THE SUGAR BEET IN INDIANA. By H. A. HUSTON.

FORMS OF NITROGEN FOR WHEAT. By H. A. HUSTON.

A COPPER AMMONIUM OXIDE. By P. S. BAKER.

DI BENZYL CARBINAMINE. By W. A. NOYES.

[ABSTRACT.]

[Published in the American Chemical Journal, 14, 225.]

Di-benzyl carbinamine was prepared by the reduction of the oxim of di-benzyl-ketone by means of sodium and absolute alcohol.

The new base melts at 47° and boils at 330°. The chloride, $C_{15}H_{15}NH_2 \cdot HCl$, separates in compact crystals which melt at 205°. The chloro-platinate, the nitrite and the di-benzyl carbinamine sulphocarbamate of di-

benzyl carbinamine, $C_{15}H_{15}NH_2 \cdot HS > C S$, were also prepared.

■ Especial interest attaches to the nitrite which is stable at ordinary temperatures, and a dilute solution of which can be boiled with very slight decomposition. In these respects the base is intermediate in its properties between the "alicyclic" bases of Bamberger and the ordinary aliphatic amines.—[Rose Polytechnic Institute, Dec. 1891.]

THE CHARACTER OF WELL WATERS IN A THICKLY POPULATED AREA. By W. A. NOYES.

[ABSTRACT.]

A table was shown giving the results of the analysis of a number of well-waters taken from wells in various parts of the city of Terre Haute. The amounts of free and of "albuminoid" ammonia in these well waters is usually very low, but the amounts of chlorine and of nitrates, and especially the latter, when compared with the amounts of the same substances found in a well water in the country east of the city show that the waters of the city wells are seriously contaminated with surface drainage. The fact that a large proportion of the cases of typhoid fever and of dysentery (477 cases out of 500 cases investigated) occur in families where well water and not hydrant water is used for drinking purposes justifies the condemnation of such well waters, even where the amount of organic matter in the water is very small.—[Rose Polytechnic Institute, Dec. 1891.]

LABORATORY AND FIELD WORK ON THE PHOSPHATE OF ALUMINA. By H. A. HUSTON.

RECENT METHODS FOR THE DETERMINATION OF PHOSPHORIC ACID. By H. A. HUSTON.

THE DIGESTIBILITY OF THE PENTOSE CARBOHYDRATES. By W. E. STONE.

THE ACTION OF PHENYL-HYDRAZIN ON FURFUROL. By W. E. STONE.

A GRAPHICAL SOLUTION FOR EQUATIONS OF HIGHER DEGREE, FOR BOTH REAL AND IMAGINARY ROOTS. By A. S. HATHAWAY.

*1. Preliminary on imaginary numbers.

The usual idea of imaginary numbers, as presented in our text books of algebra, is that they are symbols introduced for the sake of making the laws of algebra formally complete. It is implied in the name given to these numbers that they have no actual meaning. This is a mistake. The failure to mean anything in ordinary cases is not the fault of the numbers, but results from the nature of the concrete quantities with which they are generally used. Like difficulties are experienced with real numbers under similar circumstances. Let us go briefly over the list of numbers and emphasize this point.

First, the numbers 1, 2, 3, 4, that denote repetitions of a concrete quantity. If the quantity be incapable of the indicated repetition the result is imaginary. Thus: Three spaces of four dimensions. This may be comprehensible to a different order of beings, but not to us.

Second, the numbers $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, that denote partitions of a concrete quantity. Nevertheless, a space of $\frac{1}{2}$ a dimension, a school of $\frac{1}{4}$ a student, are impossibilities.

Third, the number -1 . This number must be used with quantities of two kinds such that two of equal magnitude and different kinds give, when

^oNOTE.—This preliminary on the graphic representation of imaginary numbers was not presented to the Academy. It is a simple and direct presentation of the subject without the use of analytical geometry, and on that account may be interesting to mathematicians; at the same time, it places the whole article upon an elementary basis, and makes it available to a larger circle of readers.

combined, zero result; e. g., assets and liabilities. In this case -1 reverses quality without altering magnitude, so that $1 + (-1) = 0$. But what is a farm of -80 acres? Imagine a farm that put with an 80 acre farm gives no land at all.

Fourth, the incommensurable numbers, e. g., the ratio of a diagonal to a side of a square. These require continuous quantity, and their use with quantity whose partitions are limited is impossible. What is a space of $\sqrt{2}$ dimensions, a country with $\sqrt{2}$ presidents, a man with $\sqrt{2}$ dollars in his pockets?

We recognize a number by what it can do with appropriate quantity to operate upon, not by what it can not do with inappropriate quantity. The interpretation of imaginary number requires quantity that has magnitude and different qualities. These quantities, whether geometrical or physical, may be represented by certain geometrical quantities called by Clifford steps.

The step from a position A in space to another position B has length and direction. Two steps are equal that have the same length, and the same direction; i. e., the opposite sides of a parallelogram taken in the same direction are equal steps. The sum of any number of successive steps in various directions is the step from the first point of departure to the last point reached; e. g., $AB + BC + CD = AD$. In particular the sum of two successive steps along the sides of a parallelogram is equal to the step along the diagonal. As the remaining sides in the parallelogram form equal steps added in reverse order, we learn that the order of successive steps in a sum may be changed without altering the sum.

Positive numbers operating on steps change lengths but not directions; -1 reverses direction without altering length; e. g., $-1 AB = BA$. If x be any real number we see by similar triangles that $x(AB + BC) = xAB + xBC$.

A valuable analysis may be developed by the use of steps and real numbers only. From its simplicity, and its value in physical applications, it ought to displace ordinary analytical geometry, in technical schools at least. The main difficulty is the lack of a suitable text book.

Let us confine ourselves, now, to steps in the plane of the paper, and consider the nature of the number that multiplying OA produces OB . It must alter the length of OA into the length of OB ; this is the tensor factor, an ordinary positive number. It must turn OA thus lengthened into OB ; this is the versor factor; the angle of this turn, reckoned as positive

when it is counter clockwise, is the angle of the number. Thus, let $(2, 30^\circ)$ denote a number that doubles length and turns 30° counter clockwise. Its tensor is 2, its versor is $(1, 30^\circ)$, and its angle is 30° .

After multiplying a step by $(2, 30^\circ)$ multiply the result by $(3, 20^\circ)$. Plainly the final step is $(6, 50^\circ)$ times the first step. This example of a product enables us to see at once that:

The tensor of a product equals the product of the tensors of the factors; and the angle of a product equals the sum of the angles of the factors. Hence the factors may be combined in any order without altering their product.

The definition of a sum of two numbers p and q is that $(p + q) \circ B = p \circ B + q \circ B$.^{*} Replacing $\circ B$ by $r \circ A$ we have that $(p + q)r = pr + qr$; and since the factors of a product have been shown to be interchangeable, therefore $r(p + q) = (p + q)r = rp + rq$.

We thus find that these versi-tensors follow the ordinary laws of algebraic combination. To identify them with imaginaries, notice that $(1, 90^\circ)^2 = (1, 180^\circ) = -1 = (1, -90^\circ)^2$. These two square roots of -1 are negatives of each other, for $-1(1, -90^\circ) = (1, 180^\circ)(1, -90^\circ) = (1, 90^\circ)$. So -1 has three cube roots, -1 and $(1, \pm 60^\circ)$; and so on.

It is convenient to represent versi-tensors by steps. Some step $\circ A$ is taken to represent unity; and then any other step represents its ratio to the unit step $\circ A$. Thus, if $\circ B, \circ B^1$ are steps of the same length as $\circ A$, and make angles of 60° and -60° respectively with $\circ A$, they represent the imaginary cube roots of -1 . We may use geometry to put these roots in the standard form $x + yi$, where x and y are real numbers and $i = (1, 90^\circ)$. Let BB^1 meet $\circ A$ in C ; then $\circ C$ represents, or say $= \frac{1}{2}$, and $CB = \frac{1}{2}\sqrt{3}i = -CB^1$; and from $\circ B = \circ C + CB, \circ B^1 = \circ C + CB^1$, we have $(1, \pm 60^\circ) = \frac{1}{2} \pm \frac{1}{2}\sqrt{3}i$.

This example just given makes it plain that any imaginary number may be put in the form $x + yi$, in one and only one way; and from the right triangle involved, we also see that the tensor of $x + yi$ is $\sqrt{x^2 + y^2}$, the so-called modulus in imaginaries. It is easy to show by geometry how it is that every equation with real or imaginary co-efficients has at least one root, and therefore just as many roots as its degree and no more, or even to show the whole directly. In fact, all the fundamental properties of imag-

^{*}To see that this does define the sum, try it for the case of $p = (2, 30^\circ), q = (2, 150^\circ)$, which gives $p + q = (2, 90^\circ)$. Also compare with the verification that $2 + 3 = 5$.

inaries may be made visible realities rather than symbolic results based upon certain assumptions.

When dealing with steps not limited to the plane of the paper, then (OA, n°) may be taken as the symbol of a number that turns any step that is perpendicular to OA , n° round OA as axis, counter clockwise to an observer at A , and lengthens in the ratio of the length of OA to the unit length. This is a quaternion. Quaternions whose angles are 0° or 180° are ordinary positive and negative numbers, and are called scalars. Quaternions whose angles are 90° are called vectors. The square of a vector is a negative scalar. The ordinary rules of algebra hold except that factors are not interchangeable without altering the product. A quaternion, also, cannot multiply a step that is not perpendicular to its axis. It can be geometrically represented only by two steps. A vector $(OA, 90^\circ)$ or briefly (OA) may be represented by the step OA . The value of this representation is expressed by the equations:

$$\begin{aligned} (OB) \div (OA) &= (OB \cdot OA) \\ (OB) : (OA) &= OB : OA. \end{aligned}$$

The calculus of quaternions is superior for all purposes of investigation to analytical geometry, and as its results can be immediately turned into analytical formulas, it is likely to be very much used and developed in the future. It is especially valuable in mathematical physics. An account of the system by Sir Wm. Rowan Hamilton, the inventor, was first presented to the Royal Irish Academy in 1843. The first book upon the subject, "Hamilton's Lectures," appeared in 1853.

II.

Let $ax^3 + bx^2 + cx + d = 0$ be an equation with general imaginary co-efficients. Divide this by $x - r$: the quotient is $ax^2 + (ar + b)x + (ar^2 + br + c)$ and the remainder is $ar^3 + br^2 + cr + d$. The co-efficients of the quotient, and final remainder are best found by synthetic division, which shows the general method of forming each co-efficient by multiplying the last by r and adding the next co-efficient of the original equation. The process is identical with the reduction of the compound number (a, b, c, d) whose radix is r . The test of a root is that the remainder should be zero.

The steps that represent these numbers may be constructed as follows:

Take in the plane of the paper steps OA, AB, BC, CD , representing the numbers a, b, c, d . Take any point A' , and let $A'A : OA$ be the r we

are to try in the equation for x . To find the result of the trial, construct the triangle $A' B' B$ similar to $O A' A$, and then the triangle $B' C' C$, also similar to $O A' A$. We have $O A = a$, $A' A = a r$, and hence $A' B = A' A + A B = a r + b$; also by similar triangles, $B' B = r A' B = a r^2 + b r$, and hence $B' C = B' B + B C = a r^2 + b r + c$. Again by similar triangles, $C' C = r (a r^2 + b r + c) = a r^3 + b r^2 + c r$ and hence $C' D = C' C + C D = a r^3 + b r^2 + c r + d$, the remainder sought; moreover, the co-efficients of the quotient are represented by $O A$, $A' B$, $B' C$. The problem is to so choose the first point A' that the last vertex C' of the series of similar triangles $O A' A$, $A' B' B$, $B' C' C$, shall coincide with D : then $A' A : O A$ is a root of the given equation. With the ability to construct a series of similar triangles with ease, a position for A' may be approximated to without much difficulty. Observe that $O A'$, $A' B'$, $B' C'$ are equi-multiples of $O A$, $A' B$, $B' C$. This follows from the similar triangles $O A' A$, $A' B' B$, $B' C' C$, which give $O A' : O A = A' B' : A' B = B' C' : B' C$ both as to tensor and angle parts. Hence the circuit $O A' B' C'$ represents the quotient on the new scale in which $O A'$ instead of $O A$ represents the first co-efficient a .

If the co-efficients of the given equation are all real numbers and only the real roots are sought, the method fails, since A' must be taken on $O A$ produced giving no triangle $O A' A$. In such a case, put $x = \frac{z}{m}$ where m is a given versor, say $(1, 60^\circ)$, or $(1, 90^\circ)$; the equation becomes:

$$a z^3 + m b z^2 + m^2 c z + m^3 d = 0.$$

The figure O, A, B, C, D that represents the co-efficients of this equation will have equal angles at A, B, C , viz.: the supplement of the angle of m (since a, b, c, d are real numbers, their angles are 0 or 180°). We are to seek for roots of this equation whose angles are, angle of m or angle of $m + 180^\circ$. (Since $z = m x$, therefore angle $z =$ angle $m +$ angle x .) Thus A' must be taken on $A B$ produced; and since the angles at A, B, C , are equal, it follows that the similar triangles required will have their vertices B', C' on $B C, C D$, produced, so that the construction of these triangles is simplified, e. g., to find B' , draw from A' a line making with $O A'$ an angle equal to the angle A ; that line meets $B C$ in B' . The broken line $O A' B' C'$ has its angles A', B' equal to the angles A, B , and its vertices A', B', C' in the sides $A B, B C, C D$; trials of this construction must be made until C' co-incides with D , when $A' A : m O A$ is the real root of the equation in x .

Taking $m = (1, 90^\circ)$, this is Lill's construction for the real roots of an equation with real co-efficients. Lill has devised an instrument for facili-

tating his construction, which is described as follows (Cremona Graph. Statics (Beare), p. 76):

"The apparatus consists of a perfectly plane circular disc, which may be made of wood; upon it is pasted a piece of paper ruled in squares. In the center of the disc, which should remain fixed, stands a pin, around which as a spindle another disc of ground glass of equal diameter can turn. Since the glass is transparent, we can with the help of the ruled paper underneath, immediately draw upon it the circuit corresponding to the given equation. If we now turn the glass plate, the ruled paper assists the eye in finding the circuit which determines a root. A division upon the circumference of the ruled disc enables us by means of the deviation of the first side of the first circuit from the first side of the second, to immediately determine the magnitude of the root. For this purpose the first side of the circuit corresponding to the equation must be directed to the zero point of the graduation."

Linkages might be found to perform mechanically what must be done by successive approximations in the method above, viz.: to bring the last vertex C' into co-incidence with D . Kempe has given some linkages for a different construction. [See Messenger of Mathematics, Vol. 4, 1875, p. 124.]

III.

The following constructions are given as illustrations:

(a.) Roots of $2x^2 + 4x + 1 = 0$. [Fig. I.]

As the co-efficients are all real it is preferable, and for real roots necessary, to transform the equation by putting $x = \frac{z}{m}$, $m = (1, 90^\circ)$. The equation becomes $2z^2 + 4mz + m^2 = 0$, and $OA = 2$, $AB = 4m$, $BC = m^2 = -1$. If $A'A : OA$ is a root of this equation then, dividing by m , we find $A'A : mOA$ as a root of the original equation. If this is real A' must lie on AB , produced if necessary. Remember that A' is such that $OA'A$, $A'CB$ are similar triangles and we see that the angle $OA'C$ is a right angle when A' lies on AB . Hence the circle on OC as diameter cuts AB in the sought points A' , A'' . From the figure the roots $A'A : mOA$, $A''A : mOA$ are approximately $-.3$ and -1.7 .

(b.) Roots of $2x^2 + 2x + 4 = 0$. [Fig. II.]

Here $OA = 2$, $AB = 2m$, $BC = 4m^2 = -4$. The circle on OC as diameter does not cut AB and the roots are imaginary. Since $OA'A$, $A'CB$ are similar, therefore A' is equally distant from A and B , and that distance is mean proportional between OA and CB . A circle with this mean proportional as radius and center at A or B will therefore cut the perpendicular erected at the middle point (M) of AB in the sought points A' , A'' . The circle with center at M and cutting the circle on OC as diameter at

right angles also passes through these points. Conceiving the step m. O A' drawn from A' we see that M A and A' M, A'' M are the real and imaginary components of the roots. The roots given by A' and A'' are by the figure $-\frac{1}{2} - 1.3m$ and $-\frac{1}{2} + 1.3m$.

(c.) Real root of $2x^3 + 4x^2 + 8x + 4 = 0$.

We have O A = 2, A C = 4m, B C = $8m^2 - 8$, C D = $4m^3 - 4m$. The circuit O A' B' D was drawn by aid of transparent paper turned round a pin with cross section paper underneath, after the manner of Lill's wooden and ground glass discs. The root, A' A : m O A = $\tan A' O A$, may be read off from the cross section paper to several decimal places. It is here $-.64\dots$

O A' B' D is the circuit for the quadratic equation that gives the remaining pair of roots of the cubic. The circle on O D as diameter will not cut A' B' so that these roots are imaginary.

ON SOME THEOREMS OF INTEGRATIONS IN QUATERNIONS. By A. S. HATHAWAY.

There are certain identities among volume, surface and line integrals of a quaternion function $q=f(h)$ that include as special cases the well known theorems of Green and Stokes, that are so often employed in mathematical physics. These identities were first demonstrated by Prof. Tait by the aid of the physical principles usually employed in forming the so-called "Equation of Continuity." [See Tait's Quaternions, third ed., ch. XII J.]

If dh d_1h , d_2h be non-coplanar differentials of the vector h , the theorems may be written:

$$(1) -\iiint S dh d_1 h d_2 h. \nabla q = \iiint V dh d_1 h. q$$

(The surface integral extends over the boundary of the volume integral and $V dh d_1 h$ is an outward facing element of the surface.)

$$(2) \iint V (V dh d_1 h. \nabla). q = \int dh q$$

(The line integral extends over the boundary of the surface integral in the positive direction as given by the vector areas $V dh d_1 h$.)

These theorems are analogous to the elementary theorem,

$$(3) \int_A^B dq = q_B - q_A \text{ or in quaternion notation,} \\ -\int S dh \nabla. q = q$$

It has not been noticed, so far as I am aware that these identities are equivalent to simpler identities pertaining to the operator ∇ , as follows:

$$(1)' \quad Sdh_1hd_2h.\nabla = Vd_1hd_2hSdh\nabla + Vd_2hdhSd_1h\nabla + Vdh_1hSd_2h\nabla$$

$$(2)' \quad V(Vdh_1h.\nabla) = dhSd_1h\nabla - d_1hSdh\nabla$$

In fact (1) and (2) become these (into q) when applied to the elements of volume and surface just as (3) becomes $Sdh\nabla = d_1$ (into q) when applied to the element of length.

To identify (1) and (1)', let h be the vector of the mean point of the parallelopiped whose edges are dh, d_1h, d_2h . The outward vector areas of the two faces parallel to d_1h, d_2h are $-Vd_1hd_2h, Vd_1hd_2h$, and the corresponding values of q are $q + \frac{1}{2}Sdh.\nabla.q, q - \frac{1}{2}Sdh\nabla.q$; so that sum of the vector areas into q is $-Vd_1hd_2hSdh\nabla.q$. Similarly for the other faces.

So to identify (2) and (2)', the line elements bounding the parallelogram dh, d_1h are $dh, d_1h, -dh, -d_1h$, and the corresponding values of q are $q + \frac{1}{2}Sd_1h\nabla.q, q + \frac{1}{2}Sdh\nabla.q, q - \frac{1}{2}Sd_1h\nabla.q, q - \frac{1}{2}Sdh\nabla.q$ and the sum dbq is $dhSd_1h\nabla.q - d_1hSdh\nabla.q$.

To obtain (1) from (1)' divide the given volume into infinitesimal parallelopipeds by any three systems of surfaces, one of which includes the boundary of the volume. In summing the terms (1)' the introduced interior surfaces between adjacent elements of volume are gone over twice with the vector areas oppositely directed. These surfaces balance one another, therefore, and may be dropped from the summation, leaving the volume integral equal to the surface integral over the boundary of the volume integral.

We see also that if any discontinuity in q or its derivatives exists within the given volume that the proper way to overcome this is to surround the discontinuity by surfaces and so exclude the discontinuity. Usually this alters only the surface over which the surface integral extends without affecting the volume integral.

Similarly (2) is obtained from summation of (2)' and, as every student of integral calculus is aware, (3) is obtained from dq in a similar manner.

NOTE ON THE EARLY HISTORY OF THE POTENTIAL FUNCTIONS. By A. S. HATHAWAY.

This is to call attention to an injustice that has been done by Todhunter in his "History of the Theory of Attractions" in assigning to Laplace instead of Lagrange the honor of the introduction of the potential function into dynamics. This injustice has been perpetuated by various encyclopedias, notably the Encyclopedia Britannica, and by leading text books, such as Thompson and Tait's Natural Philosophy, and Maxwell's Electricity and Magnetism. In an article in Vol. 1 No. 3 of the Bulletin of the New York Mathematical Society (Dec. 1891) I have shown conclusively that Lagrange anticipated Laplace by at least ten years in investigations on the potential. Laplace's first announcement is fixed by Todhunter as between 1783 and 1785, and this was merely through the paper of another, Legendre. Lagrange on the other hand, wrote distinctly upon that subject in 1773, 1777 and 1780; and in the last paper the notation is the same as that used by Laplace three or four years later. There is also evidence that Lagrange had begun to develop the idea of the potential as early as 1763, in connection with his celebrated generalized equations of motion.

SOME GEOMETRICAL PROPOSITIONS. By C. A. WALDO.

NOTES ON NUMERICAL RADICES. By C. A. WALDO.

SOME SUGGESTED CHANGES IN NOTATION. By R. L. GREEN.

AN ADJUSTMENT FOR THE CONTROL MAGNET ON A MIRROR GALVANOMETER. By J. P. NAYLOR.

A COMBINED WHEATSTONE'S BRIDGE AND POTENTIOMETER. By J. P. NAYLOR.

HISTERESIS CURVES FOR MITIS AND OTHER CAST IRON. By J. E. MOORE and E. M. TINGLEY.

HEATING OF A DIELECTRIC IN A CONDENSER—Preliminary note. By ALBERT P. CARMAN.

PRELIMINARY NOTES ON THE GEOLOGY OF DEARBORN COUNTY. By A. J. BIGNEY.

The geological formations in Dearborn county are the lower silurian which is found in almost every part of the county, the upper silurian occupying only a small area in the northwest part of the county and the glacial deposit of the post-tertiary times. Blue limestone is the characteristic rock. The rock is abundantly supplied with fossils, much of it being composed almost entirely of brachiopods, corals and other closely related fossils. On this account they are of little value for building purposes, the chief use being for foundation stones. Some of the hardest will weather very perceptibly in only a few years. Along the railroad at Moore's Hill, the rocks are so easily disintegrated that the cliffs appear more like immense shell banks than true rocks.

In the northern part of the county, near the upper silurian outcrop, the rock is much harder and is quarried in considerable quantities, and is regarded as a very fine quality of stone. It, however, is not equal to that which is found in Ripley and Decatur counties. Where there is no drift the soil is marly—that is, composed of lime, clay, sand, etc. In the greater part of the county and especially in the western section there is much clay; on the flats this is very tenacious. In the eastern part of the county along the Ohio drift deposits are very prominent. There is some drift at Newtown, near Lawrenceburgh, but the most important deposits are just outside the county, in Ohio county, and where it is about fifty feet thick and three miles below Aurora on the Kentucky side, above and below Wolper creek. About five miles further to the south in Boone county, Ky., still more drift is to be found. This last deposit is about on a level with the highest part of the cliff, that is, 1,000 feet. The drift at the mouth of Wolper creek, called Split-rock, is an immense mass of conglomerate fully 100 feet thick and nearly 400 feet lower than that five miles to the south. There is one perpendicular cliff that measures 73 feet high, and above this there is a rise of about 20 feet more, and how deep it extends no one has investigated. About one-fourth mile to the south, on the opposite side of a small creek, is still more deposit and one cliff is even higher than the one just described.

In the lower part of this drift, which is finer than the upper drift, gold has been found, more particularly, however, on the Indiana side.

The fossil remains in the county are rich, and a fuller report may be given at some future time. Only a few can receive our attention in this paper. Near Aurora and Lawrenceburgh numerous bones of the mastodon and mammoth have been found. The bones of a sloth and the skull of a black bear have also been found, and a few other mammals. Brachiopods, crinoids, trilobites, mollusks, bryozoa, corals, etc., are found in great abundance. The trilobites are not so numerous as they used to be, for most of the specimens have been collected—that is, the surface specimens. While exploring a mound four miles north of Moore's Hill several large specimens of the coral, *tetradium fibratum* were found. One of them required four men to place it in the wagon. One little ravine seemed to be literally filled with it. Prof. Gorby pronounced these the finest specimens of the kind in the state. They are now in the museum at Moore's Hill College.

THE CYSTIDIANS OF JEFFERSON COUNTY, IND.—By GEO. C. HUBBARD.

These fossils form an order of the crinoids, and are most abundant in the Niagara group. About thirty species, up to this time, have been found in Jefferson county, which proves it to be the richest locality in this respect in North America, if not in the world. Fifteen new species will be described and figured in the 17th report of the Geological Survey of Indiana, most of which, if not all, were collected by Mr. John Hammel. Those found belong to the genera *holocystites*, *caryocrinus* and *allocystites*. These fossils are uniformly found in shale or soft limestone, near the bottom of the Niagara group. Near Madison few have been found and these are in poor condition; but along Big creek, in the northern part of the county, they are more numerous and are well preserved. On two or three occasions I had the pleasure of accompanying Mr. Hammel to Big creek. Numerous other fossils were found, but few cystidians. If an experienced collector finds two or three good specimens in a day's search he may consider himself fortunate. A few are found in the debris at the base of the low cliffs or in the bed of the creek; more are obtained, however, by moving along on hands and knees and closely examining the various strata known to contain them, as well as the bottom of the projecting rocks above, for they are often found adhering to the lower surface of certain strata.

HUDSON RIVER FOSSILS OF JEFFERSON COUNTY, INDIANA. By GEO. C. HUBBARD.

In the Geological Report of Indiana for 1874, there appeared a list of Hudson River fossils prepared by Dr. W. J. S. Cornett, containing the names of seventy-six species and varieties. They were classified as *plantæ*, *encrinites*, *parasitic corals*, *univalves*, *orthis* and *trilobites*. Among the "orthis" were *modiolopsis modiolaris*, a lamellibranch, and *streptelasma corniculum*, a cup coral. *Tetradium fibratum*, a columnar coral, was placed under "univalves." Young and old of the same species were sometimes classed as two species. *Strophomena nutans*, which has never been found in Indiana, was included in the list. These and similar errors, together with the incompleteness of the list, call for a second attempt.

The species included in this second list have been collected chiefly by myself in the vicinity of Madison. Most of the crinoids, however, were named from Mr. Jno. Hammel's extensive collection.

The list, which is too long for an abstract, contains:

Plantæ	8 species.
Porifera	6 "
Anthozoa	25 "
Crinoidea	28 "
Stellerida	6 "
Bryozoa	14 "
Brachiopoda	32 "
Pteropoda	3 "
Gasteropoda	20 "
Cephalopoda	18 "
Lamellibranchiata	26 "
Annelida	4 "
Crustacea	8 "
<hr/>	
Total	198

Among these some ten or twelve are believed to be undescribed species.

THE UPPER LIMIT OF THE LOWER SILURIAN AT MADISON, IND.—By GEORGE C. HUBBARD.

The upper strata of the bluffs along the Ohio river belong to the Niagara group, and the lower to the Hudson river or Cincinnati group; but the exact line of demarcation between them has long been an unsettled question. The importance of this parting is recognized when we remember

that it exists wherever the silurian rocks are exposed, and that here in an altitude of more than 20,000 feet of the earth's crust, representing a period of untold ages, the greatest break in animal life occurred; but one-fourth of the genera represented in the lower silurian being found in the upper silurian, while the species are almost entirely new.

In Ripley county, along Graham creek, this parting is easily determined by means of the abundant and well preserved fossils, but at Madison this is not the case. Fossils are easily found from the level of the river to a height of 300 feet, where the *favistella stillata* bed outcrops. Above this for seventy-five feet the strata are nearly non-fossiliferous. At three hundred seventy-five feet above the Ohio the "cliff rock" outcrops, which contains characteristic Niagara fossils.

In 1859 Prof. Richard Owen, after a hasty examination, stated the *favistella* reef to be the limit. A few years later Prof. Eaton discovered *tetradium fibratum*, a Hudson river fossil, six feet higher. Subsequently, Dr. W. J. S. Cornett claimed that he had discovered a 10 inch stratum about fifty feet above the *favistella* reef containing *orthis occidentalis* and other Hudson river fossils, and announced this stratum as the last of the lower silurian.

In 1889 I commenced collecting fossils, being unacquainted with what has been stated just above. Occasionally at the head of ravines I found fossils in fallen rocks which were undescribed in any of my books on palæontology. Some were sent to S. A. Miller, of Cincinnati, who returned them, saying they were new species. This made me eager to ascertain the position from which the rock bearing them came. Mr. John Hammel and I commenced an investigation and discovered that it is situated near the summit of the precipices forming the various falls west of Madison. Immediately above we found a hard, durable salmon-colored stone which, on account of its greater resistance to decomposition, shielded and concealed the stratum beneath. The upper stratum was found to contain certain Niagara fossils, and later investigation has shown that there is an abrupt palæontological break between the two strata, corresponding to the cycles of time when the lower silurian rocks were elevated above the surface of the ocean and subjected to the disintegrating action of the elements.

By comparing the upper stratum, according to our determination, with that selected by Dr. Cornett at the stone quarry near his residence, they were found to be identical. Hence, to this gentleman belongs the honor of the discovery, our labors simply confirming his conclusion.

The only facts which militate against the validity of the limit assigned are that a survey of the two strata up and down the river for several miles shows them to be conformable; but as stated above, in Ripley county the fifty feet of non-fossiliferous rock is absent, proving non-conformability, and that the fossils, with few exceptions, are unlike others found in the Hudson river group.

THE KANKAKEE RIVER AND PURE WATER FOR NORTHWESTERN INDIANA AND CHICAGO—By J. L. CAMPBELL.

The Kankakee river is the unsolved engineering problem of Indiana.

How to secure the proper drainage of the vast basin known as the Kankakee marshes is a question which has not had a practical answer—chiefly on account of the expense necessary to carry out any of the proposed plans. A new interest in this question may be developed in connection with the problem of an adequate supply of pure water for the new cities in northwestern Indiana and of Chicago, beyond our borders.

The fact exists, although vigorously denied by citizens of Chicago, that pure water has not been obtained by the tunnel system into Lake Michigan, and it is more than probable that further extension of the system will fail to furnish pure water, and after the most costly experiments or repeated disappointments the city will seek its water supply from other sources.

The effort to keep the lake water pure by artificial drainage of the city into the Illinois river may be partially successful—but even this is doubtful—and at best changes will be enormously expensive,—literally an up-hill business.

It will not be denied that a vast territory around Chicago cannot be included in the artificial drainage system, and this territory will continue to be drained into Lake Michigan.

The mouth of the tunnel, whether located two or ten miles from the shore, is the source of an artificial stream toward which currents must tend from all directions. Into these currents the impure drainage of the city will be carried, and the water supply will be contaminated.

The extension of the tunnels doubtless will furnish less impure water, but certainly not the pure supply necessary for the health of a great city.

The practical questions connected with the question of the water supply of a great city are:—

- (1) Purity of water.
- (2) Adequacy of supply.
- (3) Elevation.
- (4) Cost of construction.

The purpose of this paper is to show that the Kankakee river furnishes a satisfactory answer to these questions.

The river takes its rise in the marsh land near South Bend, in St. Joseph county, Indiana, at an elevation of seven hundred and twenty feet above sea level, and by an extremely crooked course through Indiana, enters Illinois a few miles east of Momence. The length of the river in Indiana is nearly two hundred and fifty miles.

According to a survey made by the author of this paper for the State of Indiana in 1882 this channel could be reduced for better drainage to less than one hundred miles.

The chief tributary of the Kankakee is Yellow river, which rises in the eastern part of Marshall county.

The country adjacent to the river is a broad plain, varying in width from one to twenty miles, along the borders of which are sand ridges which give to the region the designation of the Kankakee Valley, and which have produced the erroneous impression that the marsh is a low irreclaimable swamp, whereas the fact is that it is an elevated plateau with a mean level of ninety feet above Lake Michigan and six hundred and seventy feet above the ocean.

The plateau has a slope westward of one foot per mile.

The water of the Kankakee is remarkably pure and clear, and is regarded by all who have used it as exceptionally healthful.

Iron is found in solution, which doubtless adds value to the water for general purposes.

The bed of the Kankakee and of its tributaries generally is fine sand and gravel, and the underlying strata throughout the valley are fine sand increasing to coarse gravel. Clay beds are rare and there is no stone along the stream throughout Indiana. The overlying loam varies in thickness from a few inches to several feet, and the surface generally is an unreclaimed marsh in which coarse grass, wild rice and weeds grow in the greatest luxuriance.

The crookedness of the stream is readily explained by the instability of the sandy strata through which it flows—the twelve inches of surface slope being reduced to four inches, measured in the channel of the stream.

The sandy substratum makes the entire valley a vast filtering basin—a great lake filled with sand and gravel, whence issues the pure and limpid water of the Kankakee river.

This is a satisfactory answer to the first and most important question concerning a city water supply.

The second question is the adequacy of supply.

The most convenient point on the Kankakee for starting a pipe line to Chicago or any of the new cities in the northwestern part of Indiana is in township 33 north, range 6 west, not far from the boundary line between Porter and Lake counties.

The drainage area of the basin above this point is about twelve hundred square miles, which is four times the area of the Croton basin whence is derived the water supply of New York.

The sluggish flow of the river, due to the fall of only four inches to the mile, substantially makes this basin of over a thousand square miles a reservoir more than sufficient for the greatest demands, and satisfactorily answers the second general question concerning a city supply.

In answer to the third and fourth general questions, the state survey of 1882 shows that the elevation of the initial point already designated as the proper beginning place for a pipe line is seventy-three (73) feet above lake Michigan, or sixty-nine feet above the Illinois Central depot on the lake front of Chicago, or fifty-one feet above the railway station at Toleston.

The distance from the initial point to Chicago is less than fifty miles and to Toleston twenty-five miles.

The sand ridge on the north side of the Kankakee has a probable altitude of fifty feet, and in the absence of a survey it cannot be stated whether it would be better to excavate through this ridge for the pipe line or to pump the water to the summit. If it is found feasible to excavate for the line a flow of water by gravity alone can be secured from the Kankakee to the lake front in Chicago, with a fall of one foot per mile, into the receiving reservoir twenty-three feet above the level of the street. The first Croton aqueduct has a fall of forty-seven feet in thirty-eight miles.

If it is found more expedient to pump the water to the summit it is possible that an open channel along the surface of the ridge could be constructed so as to reduce the closed pipe line to twenty-five miles and to deliver the water in Chicago with a standpipe pressure of from fifty to seventy-five feet.

These questions cannot be satisfactorily answered until after a careful survey has been made.

The importance of this enterprise cannot easily be overestimated, and the cost of the work, even if it should reach millions, will be insignificant in comparison with the results to be obtained.

EXPLORATIONS OF MT. ORIZABA. By J. T. SCOVELL.

VARIATIONS IN THE DYNAMICAL CONDITIONS DURING THE DEPOSIT OF THE ROCK BEDS AT RICHMOND, IND. By JOSEPH MOORE.

THE RELATION OF THE KEOKUK GROUPS OF MONTGOMERY COUNTY WITH THE TYPICAL LOCALITY. By C. S. BEACHLER.

COMMENTS ON THE DESCRIPTIONS OF SPECIES. By C. S. BEACHLER.

ON A DEPOSIT OF VERTEBRATE FOSSILS IN COLORADO. By AMOS W. BUTLER.

TOPOGRAPHICAL EVIDENCE OF A GREAT AND SUDDEN DIMINUTION OF THE ANCIENT WATER SUPPLY OF THE WABASH RIVER. By J. T. CAMPBELL.

SOURCE OF SUPPLY TO MEDIAL MORAINS PROBABLY FROM THE BOTTOM OF THE GLACIAL CHANNEL. By J. T. CAMPBELL.

NOTES ON A KANSAS SPECIES OF BUCKEYE. By W. A. KELLERMAN.

PHOTOGRAPHING CERTAIN NATURAL OBJECTS WITHOUT A CAMERA. By W. A. KELLERMAN.

ON THE OCCURRENCE OF CERTAIN WESTERN PLANTS AT COLUMBUS, OHIO. By AUG. D. SELBY.

[ABSTRACT].

It is my purpose in this paper to point out two features of the flora in the vicinity of Columbus, Ohio, which combine to present in it a representation of western plants; as a result of the one, we find in that locality the beginning of western species, and by the other are to note the comparatively recent introduction of a good many far-western and southwestern plants, some of which appear there, perhaps, for the first time east of the Mississippi river.

In Central Ohio there is a marked blending of eastern and western species of plants; east and southeast of Columbus but a short distance will bring one into the typical Appalachian flora, while to the westward the entire half of the state is underlain by the great limestone formations and with the outcrop of the corniferous limestone, the first to be met with traveling westward, plants of a well-marked western range begin to appear. This feature was referred to by Prof. J. S. Newberry * in 1859. He points out a peculiar facies due (in part) to the presence of a number of the prairie plants of the west here on the eastern limits of their range.

The following species may be cited as illustrating this fact, all occurring near Columbus:

Erysimum asperum, *Trifolium stoloniferum*, *Cornus asperifolia*.

Aster azureus, *Aster Shortii*, *Helianthus doronicoides*.

Camassia Fraseri, *Bouteloua racemosa*.

But it is to the presence of a number of distinctly western and southwestern plants introduced by wholesale, as it were, that more particular attention is directed.

Columbus, in common with all railroad centers through which shipment

* Ohio Agricultural Report, 1859, p. 240.

of products from the west regularly occurs, is in a position to receive the plants thus dropped. *Artemisia biennis* and *Verbena stricta* have been received by this means; the latter is especially abundant around the railroad intersections. In addition to this opportunity, an exceptional one, as it would appear, is presented by the permanent quarters of a circus and menagerie (Sells Brothers').

On the grounds about these winter quarters near Columbus, about twenty species of plants have been introduced and more than half of them have not appeared elsewhere in the vicinity. The range and distribution of the plants found is such as to increase the interest attaching to their appearance. The seeds were evidently brought upon the return at the close of the season, carried in cars, cages, wagons, or preserved in the intestines of animals. The litter of cars and cages seems to the writer the most likely vehicle for the seeds of the larger number of plants found.

Below are the species found on the circus grounds and appearing by some agency connected therewith; those introduced independently at other points in the county are marked with an asterisk; accompanying certain ones the range of the species is copied from the Manual or Synoptical Flora:

Callirrhoe involucrata, Gray. Minnesota to Texas.

Erodium cicutarium, L'Her.

Clarkia pulchella, Pursh. Western Montana and westward.

Amphiachyris dracunculoides, Nutt. Plains, Kansas and southward.

Aster pauciflorus, Nutt. Kansas and west (?).

Artemisia annua L.

Dysodia chrysanthemoides, Lag.*

Gutierrezia Texana, Torr & Gray. Sterile plains throughout Texas.

Helenium microcephalum, DC. Southern Texas and adjacent Mexico.

Helenium nudiflorum, Nutt.

Helenium tenuifolium, Nutt. West of Mississippi river.

Parthenium Hysterophorus, L. Throughout Eastern and Central Texas, also east of Mississippi river.

Solanum rostratum, Dunal. Plains of Nebraska to Texas, spreading eastward.

Verbena angustifolia, Michx.

Monarda citriodora, Cerv. Nebraska to Texas.

Plantago Patagonica, Jacq., var *aristata*, Gray.*

Amarantus spinosus, L.

Chenopodium ambrosioides, L. var. *anthelminticum*, Gray.

Croton capitatus, Michx.

Avena fatua, L.

Of those here much beyond their assigned limits, three show decidedly weedy tendencies. They are *Solanum rostratum*, *Dysodia chrysanthemoides* and *Parthenium hysterophorus*. The two last named promise to become permanent additions to our flora, undesirable though they may be.

The circus is at present in Australia and we shall watch with interest to secure anything that may be brought from there.

BIOLOGICAL SURVEYS. By JOHN M. COULTER.

SOME STRANGE DEVELOPMENTS OF STOMATA UPON *CARYA ALBA* CAUSED BY PHYLLOXERA. By D. A. OWEN.

[ABSTRACT].

Upon the upper side of the leaf of *Carya alba* are found some hemispherical and conical galls produced by the little insect *Phylloxera*. These galls are the receptacles for the eggs, or nest of these insects.

The stomata in leaves uninjured are all found upon the lower surface. But in those containing galls there are seldom any stomata found in the epidermis just beneath the gall. The upper side is entirely free from stomata with the exception of the gall itself. In no case was any gall examined in which stomata were not found upon the upper surface. And with but one or two exceptions no stomata were found upon the under surface just beneath the gall.

Surrounding and within the opening of the gall upon the under side of the leaf minute hairs were found, all extending outward as if to guard the opening against the entrance of an enemy.

There seems, from the above, to be an intimate relation existing here between the plant and animal.

PRELIMINARY PAPER ON THE FLORA OF HENRY COUNTY, IND. By T. B. REDDING and MRS. ROSA REDDING MIKELS.

A NEW COMPOUND MICROTOME. By GEO. C. HUBBARD.

Wishing to prepare some slides exhibiting the structure of various animal tissues and organs, but having no microtome, I made one of wood chiefly, at a cost of thirty cents and two or three days' labor.

The principle of the machine is to prepare sections by quickly forcing the tissue, supported on a carrier attached to the circumference of a 12-inch wheel, across the edge of a razor, which is brought automatically a slight distance nearer the tissue at each rotation of the wheel.

The base of the machine is a heavy board about thirteen inches long by eight in width. At the middle of each side inflexible standards are erected and adjustable bearings provided, the centre of the opening in each being six and one half inches above the board. In these bearings rests the axis of the 12-inch wheel, which is turned by means of a crank.

The support for the tissue consists of a round brass disc of any convenient size attached at its centre to one end of a short cylindrical rod. This rod fits into a corresponding orifice extending through the middle of a half-cleft sphere, which fits loosely in a corresponding socket in the circumference of the wheel. One side (the one opposite to the automatic feeder) of this socket is made adjustable by removing a round bit of wood and inserting in its stead a concave disc, which is attached to the short end of a straight lever extending down the side of the wheel to near the axis. A screw passing loosely through the lever about an inch from the center of the disc into the wheel serves as a fulcrum. Let this lever be called A. The long arm of A is moved by means of a circular wedge turning upon the round end of the wheel's axis. The thick part of the wedge is allowed to project four or five inches beyond the line of the circumference of the circle, and provided with a knob, thus forming a second lever, B, to which the power is applied. Instead of B and the wedge, a thumb-screw may be screwed through the long end of A, its end turning against the side of the wheel.

When the tissue has been fastened to the brass disc in the usual way, its round support is thrust into the opening of the ball. The carrier is turned and bent in any direction and pushed out or in until the tissue is in the right position with regard to the razor. A slight force exerted on the knob of B moves B forward thus causing a thicker part of the circular wedge to pass between the wheel and the long arm of A, which forces the concave disc at the other arm against the half-cleft ball, thus causing it to grip firmly the tissue support. If a thumb-screw be used, it must be turned three or four times to produce the same effect.

At one end of the board forming the base of the machine is fastened, by means of two hinges, a perpendicular piece of wood six and one-half inches long, cut so that there are three arms above. Each of two of these has an opening at its upper extremity suitable for receiving the razor, and is provided with a set-screw for clamping the razor.

To the third arm is attached a nut in which work the threads of a bolt, which extends horizontally to near the axis. The head of the bolt is attached to the centre of a wheel some four or five inches in diameter. The bolt now forms the axis of this wheel and must be supported at the wheel by an unyielding bearing. Turning this wheel once in the right direction pulls the razor forward a distance equal to that between the threads, which we shall suppose to be one-sixteenth of an inch.

On the face farthest from the razor of the small wheel, about twenty round brads are inserted near the circumference *at equal distances apart*, and *all the same distance from the centre of the bolt*. If the wheel be rotated the distance between two brads, the razor is drawn forward one three hundred and twentieth of an inch.

A small rectangle of tin or brass about three-fourths of an inch long is bent at right angles, and one edge is cut to form a slightly concave set of twelve vertical teeth of equal size, to turn the 4-inch wheel by pushing against the brads. If ten of the teeth are used, one tooth will move the razor forward one thirty-two hundredth of an inch.

This ratchet is now fastened to the side of a long horizontal lever, which is secured at one end to an upright support. The other arm rests upon an eccentric on the square end of the axis of the 12-inch wheel. Turning this wheel causes an up-and-down motion of the ratchet. The eccentric has a rectangular opening so that it may be slipped upon the axis and made more or less eccentric. It is held in any desired position by a set-screw. A peg, or better a screw with the head removed, projects from the under side of the lever just mentioned into a groove made in the circumference of the eccentric. This groove must be so arranged, that when the ratchet is rising, a tooth catches under a brad; but when it ceases to rise, a short oblique portion of the groove moves the tooth from under the brad. The groove now resumes its straight course so as to prevent the next tooth above from coming in contact with the brad as the ratchet descends. Another short oblique portion of the groove brings this tooth under the brad. As one brad escapes from the top of the ratchet, another enters at the bottom.

To prevent any lost motion, and to push back the razor support when the 4-inch wheel is turned backward, a strong spiral spring may be placed on the bolt so as to extend from the bearing to the nut.

With the above described arrangement of parts, sections can be cut one thirty-two hundredth of an inch thick. By shifting the eccentric so that alternate teeth work, the sections are of double the thickness, etc. But little eccentricity is needed, about one-sixteenth of an inch being sufficient when each tooth of the ratchet is employed.

ON THE ORGANOGENY OF COMPOSITE. By G. W. MARTIN.

ON THE DEVELOPMENT OF THE ARCHEGONIUM AND APICAL GROWTH IN THE STEM OF *TSUGA CANADENSIS* AND *PINUS SYLVESTRIS*. By D. M. MOTTIER.

[ABSTRACT.]

This work consisted in a study of the development of the archegonium and the meristems of the stem. The results obtained in reference to the archegonium differ from those of Strasburger in that the neck of that organ in *Tsuga* consisted of two cells in as many cases as where one only was found, and very rarely three. In *Pinus* the neck of the archegonium was found to be made of two layers of cells, four in each layer, lying one above the other, instead of one layer.

As regards the growth of the stem it is argued that we can not say with certainty that growth proceeds from a single initial cell, as claimed by DuRoi for the Gymnosperms.

PRELIMINARY NOTES ON THE GENUS *HOFFMANSEGGLIA*. By E. M. FISHER.

DEVELOPMENT OF THE SPORANGIUM AND APICAL GROWTH OF STEM OF *BOTRYCH-IUM VIRGINIANUM*. By C. L. HOLTZMAN.

THE FLORA OF MT. ORIZABA. By HENRY E. SEATON.

As botanist of the J. T. Scovell expedition during July and August, 1891, collections were made by the writer on Mt. Orizaba through a range of 3,000 to 14,000 feet.

The first collections of importance on the mountain were made by Fredrik Liebmann in 1841. Others who have collected on the mountain, and especially in the valley of Orizaba and Cordoba, are Henri Galeotti, August Ghiesbreght, E. Bourgeau, M. Botteri and Frederick Mueller. The volcano of Orizaba is described by Liebmann as the most interesting mountain in North America. It has a latitude of 18 degrees and lies surrounded by the very fertile country of southern Mexico. It is only ninety miles from the gulf, and having such a situation there is presented upon its eastern slope every phase of vegetation from tropical to alpine.

The region in the vicinity of Cordoba, at an elevation of 3,000 feet and a distance of sixty miles from the coast, has a sub-tropical vegetation. Palms grow in abundance and orange, banana and coffee trees attain a high degree of cultivation. Prominent among the families that make up the shrubby and herbaceous flora are the Malvaceæ, Leguminosæ, Rubiaceæ, Compositæ, Asclepiadaceæ, Convolvulaceæ, Solanaceæ, Euphorbiaceæ and Bromelliaceæ, besides the grasses, sedges and ferns.

The town of Orizaba, 1,000 feet higher up the mountain, has a somewhat less tropical vegetation in the way of cultivated plants. At this altitude the Compositæ have their greatest display. The Helianthoidæ are the forms most abundant, and not only are they characteristic of this particular region but have in Mexico their greatest concentration, amounting, it has been estimated, to thirty-two per cent. of the species and two-fifths of the genera of all the Compositæ of the country. The sub-order Eupatoriaceæ ranks second in numerical strength, the genera *Eupatorium* and *Stevia*, however, contributing nearly all the species. The Asteroideæ have but little representation in the forms *Aster*, *Erigeron* and *Solidago*, which are so characteristic of the north. All the other sub-orders of the family are present excepting the Arctotideæ and Calendulaceæ, which are confined principally to southern Africa.

Collections were made at three successively higher stations till the altitude of 9,000 feet was reached, and this zone of 5,000 feet above the town of Orizaba may be considered as the temperate region, and that above 9,000 feet as alpine. Many plants of the sub-tropical region extend their range to the temperate and even to the alpine district, this being especially true

of the low growing plants like *Oxalis*, *Stellaria* *Trifolium* and several of the *Malvas*. The temperate zone is characterized, nevertheless, by many genera and families that are not present or are hardly noticeable in the more tropical regions. The genus *Salvia* and order *Lythraceæ* have a strikingly large distribution. Of these latter *Cuphea* is the most conspicuous element, growing in great abundance under all conditions of soil and moisture. There are many representatives from the *Geraniaceæ*, *Borraginaceæ*, *Scrophulariaceæ*, *Verbenaceæ* and *Acanthaceæ*, which take the place in a great measure of the *Malvaceæ*, *Rubiaceæ*, *Asclepiadaceæ*, *Solanaceæ* and *Euphorbiaceæ* in the tropics.

Great and rapid changes are experienced in the flora as the slopes are ascended above 9 000 feet, and there are well marked zones for the distribution of plants till the limit of vegetation is reached. Between 9,000 and 10,000 feet, species of *Sisymbrium*, *Lepidium*, *Geum*, *Epilobium*, *Enothera*, *Krynitzkia*, *Mimulus*, *Castilleia*, *Verbena*, *Salvia*, *Plantago* and *Chenopodium*, are the most characteristic forms of the herbaceous flora. Prominent among the *Compositæ* are *Steria*, *Avillea*, *Dahlia* and *Tagetes*, and besides *Eupatorium* and *Baccharis* the shrubby flora is represented by *Rubus*, *Symphoricarpos* and *Buddleia*. Prominent among the grasses are *Agrostis*, *Muehlenbergia* and *Bromus*, and the ferns are represented by *Adiantum*, *Cheilanthes*, *Woodsia* and *Asplenium*.

Between 11,000 and 12,000 feet the forests are entirely of pines and spruce. The greater part of the herbaceous flora at this altitude is composed of *Cerastium*, *Lupinus*, *Acaena*, *Eryngium*, *Arracacia*, *Halenia*, *Penstemon*, *Cnicus* and *Stenanthium*. *Penstemon* and *Stenanthium* are exceedingly abundant, though possessing a very limited range.

At 13,000 feet the vegetation consists principally of *Cerastium*, *Arenaria*, *Potentilla*, *Castilleia* and *Lithospermum*. The pine woods, beginning at 7,000 feet, disappear at 13,000 feet, excepting stunted forms that continue to 14,000 feet. At 13,500 feet the vegetation becomes scantier and the slopes more sandy and beset with masses of sharp pointed rocks. The dry, sandy soil produces species of *Draba*, *Gnaphalium*, *Senecio*, *Cnicus*, *Agrostis*, *Bromus* and *Asplenium*. Even at 14,000 feet on the higher slopes, just at the snow line, there exists quite a varied vegetation, with species of *Draba*, *Sisymbrium*, *Gnaphalium*, *Cnicus*, *Asplenium* and the grasses of the sandy plain below. This was the highest point collections were made, but several species extend their range a hundred feet higher, and Dr. Scovell secured a *Draba* at 15,000 feet.

The collection numbered 510 species, distributed among 459 Phanerogams and 51 Pteridophytes. In this limited space no mention has been made of species, the object being only to present the general character of the flora of the mountain, as shown by the distribution of certain families and genera. A more complete report will be published later, with notes on species.

AN APPARATUS FOR DETERMINING THE PERIODICITY OF ROOT PRESSURE. By
M. B. THOMAS.

[ABSTRACT.]

The paper presented the need of a self-registering apparatus for determining the periodicity of root pressure, and gave an outline of the ones now in use, all of which were seen to need constant attention. An apparatus made in the following manner was suggested. The base of the instrument is about 1'x3'' and is supported by legs about 3'' high. About 10'' from one end and in the center of the base is erected a standard about 2' high and 4'' in width. On the short end of the base and near the post is fastened a set of strong clock-works. The works are covered with a box and the end of a cylinder 6'' in diameter and 1' 10'' high is fastened to the hour pinion of the clock by means of a pin passing through a hole in the end of the pinion and fitting in a slot in the end of the cylinder. The top of the cylinder is held in place by a pin passing through a support from the main pillar and a hole in the end of the cylinder. To the large upright pillar is fastened a U tube of about ½' in diameter; one arm being nearly as high as the pillar and the other but half the height. The tube is filled with mercury to within about an inch of the top of the short arm. The stem of the plant is cut off near the base and placed in position. An inverted U tube is fastened to the stem in the usual way by means of a rubber tube fastened with wire while the other end of the U tube is connected with the larger one in the same way. The small U tube is filled with water through an opening in the top. The cylinder which is made of light tin is blackened by revolving it slowly in the flames of a candle or gas jet. The indicator consists of a light steel wire with a cork at the end somewhat smaller than the diameter of the tube. This rests on the mercury. It is then at the top of the tube bent twice at right angles and allowed to extend to the bottom of the cylinder where it is again bent twice at right

angles and the end allowed to rest against the smoked surface of the cylinder. A pin driven in the pillar prevents the wire from turning to one side because of the friction of its end with the cylinder. As the root absorbs water the pressure upon the column of mercury increases, causing it to rise in the tube lifting the cork and indicator with it. The indicator then marks a continuous spiral course on the cylinder. The hourly variation can be studied by observing the distances between the lines. The supply of water given to the plant must be kept constant. An eight day clock should be used and the apparatus need scarcely be touched until the plant is exhausted.

THE DISTRIBUTION OF TROPICAL FERNS IN PENINSULAR FLORIDA. By LUCIEN M. UNDERWOOD.

To one who makes a visit to Florida for the first time, constant surprises appear on every hand; sand, palmetto and spanish moss were expected, but the excess of dry pine lands over hamaks, the multitudinous lakes of every size and shape, the comparative purity of the waters, and the variety of elevation apparent in short distances, formed elements that were not looked for and that serve to modify the botanical features of the country to a considerable extent. The river systems are mostly in a north and south direction, and the rivers are sluggish and often rather deep. Throughout the interior of the state, lakes of all sizes are abundant; twenty-five to thirty lakes in a single township (six miles square) is not unusual. Most of the small lakes are without outlets, and frequently stand in deep hollows. Sometimes you may find two lakes a half mile or so apart with a difference of elevation from 50 to 100 feet. Except for a slight discoloration from roots, the water is remarkably clear and few algæ were seen. With the exception of river borders where clay and black mud are found, there is everywhere the loose gray sand that rolls under foot of man or beast, making progress slow and tedious, that supports no turf and only a scattered vegetation, that absorbs moisture rapidly, and that contains a fine dust that filters through the clothing and renders one black and grimy after even the shortest tramp. Occasional swamps occur where a former pond has given way to a bog, or where a small stream is choked up and thus overflows its usual bounds; here a variety of deciduous trees stand thick together interwoven with the omnipresent and exceedingly spiny

Smilax of many species. Here and there are occasional overflows of larger streams where the cypress flourishes, but pine is the prevailing forest growth. From Gainesville southward through Ocala and on toward the center of the state is found higher ground which, long before the phosphate fiend had bored the rocks for paying phosphate, was pitted with natural sink holes and caves where moisture is ever present and where the frosts rarely penetrate. These extend to Brooksville and beyond, and are found on either side of the Withlacoochee river. Further southward and including the lower fourth of the peninsula are the low everglades with saw grass lakes and scrub-palmetto barrens soaked with water during the spring rains, which is reduced to scattered shallow ponds in the dry season.

Although Florida possesses a larger number of ferns than most of the states of the Union (43), and of these more than half (24) are found in no other state, one who visits the state in the winter season will be impressed with the rarity of ferns unless the state is reached before the usual December frosts have cut down the fronds. Along the rivers and wherever moisture is abundant *Woodwardia virginica* grows luxuriantly in its season as the most abundant fern. With it appear two of the *Osmundas* though far less abundant than in northern swamps. It seems out of harmony with our preconceived notions to find the fertile fronds of *O. cinnamomea* growing from a circle of older sterile ones, but this condition is common even in January. Farther down the state *Blechnum* and *Aspidium unitum* and some other species are occasional, but are rarely abundant, at least in the upper two-thirds of the peninsula. In drier land *Pteris aquilina* grows in a more or less stunted condition, but in the more tropical parts of the state it grows occasionally to an excessive height. Next to *Woodwardia* it is probably the most abundant species. *Polypodium incanum* is everywhere found to a limited extent on tree trunks, but is found in profusion only in the southern third of the state. At Orange Bend we found the *mucronata* form of *Marsilia vestita* in abundance rooting in sand and mud. While this is more or less common from Oregon and Dakota to Southern California and Texas it has never been reported before from east of the Mississippi. Its presence in Central Florida becomes almost as interesting a problem as that of its congener, *M. quadrifolia*, in Northwestern Connecticut. No fruit could be found in January, but in the latter part of March fruit was found in great abundance.

The uncertainty of frosts makes the collecting period difficult to predict. Sometimes the fall frosts hold off until January, and often cease to be

troublesome after the middle of February. In other years they appear anywhere from December to April. Often they are local, while again there will be a general freeze that will cut down all tender vegetation. The "great frost" of March, 1886, was sufficiently severe to kill the young fruits of the cocoanut as far south as Lake Worth, and killed out much of the *Vittaria* as far down the gulf side as Manatee. During last winter several frosts appeared in January as far south as the lake region, and on the 8th of April the *Woodwardias* along the St John's from Sanford to Palatka were all drooping from a cutting frost. Of course in secluded places ferns may be found at any season, but only in comparatively frostless winters can they be seen to advantage in the northern half of the state.

The rarer ferns of Florida are tucked away in inaccessible quarters and are not to be found without much searching. Of the ferns peculiarly tropical three groups may be considered: (1.) The swamp species. (2.) The epiphytes. (3.) The lime-rock ferns. Of the swamp species, *Blechnum serrulatum* is perhaps the most common; ordinarily this species grows from two to three feet high, but toward its northern limit along the outlet of Lake Dora we found robust forms six and seven feet high. *Nephrolepis exaltata* we found in profusion at the same place growing on decaying stumps and logs. In fact this seems to be its usual habitat instead of palmetto trunks, as so often stated. *Aspidium unitum* has much the same range. *Polypodium phyllitidis* comes north on the gulf side as far as the Manatee river and we found it not uncommon at Lake Worth. *Acrostichum aureum* frequents the brackish borders of tidal streams occasionally encroaching below high water mark. In the west coast it comes up as far as Tampa, and on the Atlantic coast it is more or less common throughout the Indian river country and comes well up to the coast above Titusville. We did not find *Asplenium serratum* in any part of the state visited, though Garber reported it from Manatee in 1879. It more properly belongs in the really tropical portion of Florida.

Of the epiphytic species *Vittaria* and *Polypodium aureum* come furthest north. We found abundance of the former between lakes Griffin and Harris; the latter may be seen occasionally in the vicinity of Lake Monroe, though it is more common below Titusville on the east and Tampa Bay on the west. *Vittaria* grows pendent on palmetto trunks at every height and in every stage of growth from prothallus to mature plant.* Its northern

*It may be of interest to state that a species of liverwort, *Riccia reticulata*, was based on the prothallus of this fern.

limit as we found it is in Lake county. *Polypodium aureum* usually grows just under the clustered leaves of the cabbage palmetto, often at a height of twenty-five or thirty feet. *Ophioglossum palmatum* comes as far north as Manatee where we found the sterile fronds in February after a weary search, for it grows well up on the palmetto trunks, burying its roots deeply between the old decaying bases of the palmetto leaves. He who attempts to climb the palmetto trunk is not usually anxious for the second trip.

The *Ophioglossum* fruits in April or perhaps the last of March and is the most peculiar member of its order, since most of its congeners are terrestrial in habit. The remaining epiphytes have not been found north of the tropical portions of Florida, which include the Keys and the region of Biscayne Bay.

The rock-loving species have a more extensive distribution as they grow in places beyond the reach of ordinary frosts; in the high hamak region to which allusion has been made, several of the tropical species linger in portions of Florida, too cold even for the successful culture of the Orange. In the various limestone sinks about Ocala may be found *Pteris cretica*, *Asplenium rhizophyllum*, *Asplenium firmum*, *Polypodium pectinatum*, *Aspidium patens* and *Adiantum tenerum*. From this same region the rare *Phegopteris tetragona* was collected, but its discoverer holds the exact locality in secret, and furnishes herbarium specimens at 50 cents apiece. While this method of procedure is not what is expected among botanists, one who knows the difficulty and expense of securing some of the rare Florida ferns can scarcely have the heart to criticise too harshly.

A still more interesting locality for the rock ferns is on the Withlacoochee river, two and a half miles below Istachatta. This town which makes considerable display on the maps, consists of two houses and a store and must be reached from Pemberton the nearest railroad station by boat or private conveyance. As the exact locality has never been defined it was by merest chance that we met Mr. F. M. Townsend, the proprietor of the store at Istachatta, who conducted Donnell Smith to the same location in 1883. The locality, which is on the premises of Mr. George K. Allen, was reached just at nightfall. Here, besides a much greater profusion of the species found at Ocala, are found the rare and variable *Phegopteris reptans* and a great profusion of *Aspidium trifoliatum*. Other stations are found near Brooksville and farther down the river on either side. In these sheltered sink holes, protected from frost and so far removed from sunshine as to retain moisture in the driest season, these relics of a tropical flora still

persist, never attracting the attention of either the native "cracker" or the northern migrant, both of whom stare alike at the botanist and his outfit and doubtless wonder what he can want of "ferns." While the higher flora of the tropics does not begin to appear until we reach the Manatee on the west coast and Lake Worth on the Atlantic seaboard, these outliers of the tropical flora extend from two to three degrees farther north, and represent the stragglers in the southern retreat that has marked the southern extension of the peninsula from reef to key and from key to everglade.

With all the information that could be gathered before starting we found that the experience of the winter was necessary to learn the peculiarities of the country and the best localities for exploration and especially how to reach them after they were made known, for of all English speaking countries to learn how to reach a given point Florida is one of the worst in our experience. To point out some of the best localities for future exploration is partly the object of this paper. We would like also to protest against the stupid method of sending out collectors to look simply for the higher vegetation of a new region. Mosses and hepatics, algae, lichens and fungi form just as much a part of the flora of a country as do the seed plants and ferns and often furnish more valuable information regarding the true character of a region than can be gained from a study of the higher flora alone.

Four distinct regions in Florida suggest themselves as likely to yield not only more interesting tropical ferns than have yet been brought to light, but a rich harvest of new facts and species illustrating the nature and distribution of the tropical flora of the peninsula. This, however, will only be possible when the critical botanist gets away from his dried herbarium fragments and studies the flora face to face in its native fastnesses. Then only can biological surveys prove a success. These regions are:

1. *The river regions of West Florida.*—The Withlacoochee, especially from Pemberton Ferry to the mouth, and including lakes Tsala Apopka and Penasoffkee on either side, the Manatee, the Myakka and the Peace. Explorations along these rivers can best be made in boats* and are likely to well repay the cost, for while nearly all have been somewhat visited by botanists, the country has been *skimmed* rather than explored.

2. *The interior lake region of South Florida.*—This would involve a trip from Kissimmee southward down the chain of lakes to Okeechobee and

*The region of Lake Tsala Apopka and Lake Penasoffkee could best be explored with a horse and wagon, though the development of phosphate beds in Citrus county is likely to extend the public means of conveyance. Railroads in Florida are too slow and uncertain for much dependence for short trips.

and then westward through the drainage canals and the Caloosahatchee river to Punta Rassa. This means from 200 to 250 miles by boat, subjection to considerable hardship, and could only be undertaken by a party.

3. *The Keys*.—Within the triangle whose base is a line running from Key West to Key Largo, and whose apex is at Punta Rassa, there are myriads of small islands, all lying in the tropical portion of Florida, which have never received anything like a thorough botanical exploration. These can only be explored by boat. A small sailing craft can be obtained at Tampa, Manatee, or Key West, for \$40 a month furnished with a sailor who will also act as cook. Board is cheap, for game and fish are abundant, while other supplies will have to be obtained at the point of embarkation. The scattering trips that have already been made to this region have yielded some of the rarer ferns, to say nothing of extensive additions to the higher flora of the state, ranging from a new genus of palms down. Unless it be among the algae not a single specimen of the lower cryptogams has been collected in this region.

4. *The Biscayne Bay region*.—The fairest spot we found in Florida during last winter was Lake Worth. The northern tourist who leaves this out misses the best of the state. Here the climate is that of Southern California, mild and balmy like all Florida, and yet with the invigorating tonic that nearly all the rest of Florida sadly lacks. Here, too, if you are fortunate enough to stop at Oaklawn on the mainland, you will find as we did the first square meal in Florida, served by the genial judge of Dade county, who is also the proprietor of the best hotel on the lake. Here was the first real taste of the tropics. Tropical fruits and cocoanuts in profusion, mangroves without trunks set up on spider-like roots, banyans, and a profusion of strange shrubs and trees. It was only when too late to avail ourselves of the trip that we learned how to reach Biscayne Bay from the Atlantic side. Of course it could be reached from the Gulf side by boat,* but in vain did we try to learn whether there was an overland passage from Miami to Lake Worth. Here we found that a solitary mail carrier tramps the distance (about 60 miles) once a week, thus bringing the two settlements of Dade county within reach of each other. He goes up and down the beach, for there is no other path. Life saving stations are scattered along the coast at intervals of about 25 miles, and the only places where there is real danger is at the inlets, which, during the high seas are difficult to nav-

*Miami may be reached from Tampa by a tri-weekly mail steamer to Key West (fare \$10), thence by sailing vessel which carries bi-weekly mail to Miami (fare \$4).

igate in the frail barks that serve for ferries, and the inlets are usually infested with both sharks and "gators." The best collecting ground is usually within 300 yards of the coast line. The ordinary guide books state that "there is nothing of interest below Lake Worth," but one who has seen the country below from a botanical standpoint says "there is nothing above Lake Worth." Botanically this is doubtless the most interesting region of all Florida. The part between Lake Worth and Miami has so far as we know never been trodden by a botanist. Around Miami and on the neighboring Keys have been found most of the remaining tropical ferns of Florida, viz.: *Polypodium Swartzii*, *Asplenium serratum*, *A. dentatum*, *Nephrolepis acuta*, *Pteris longifolia*, *Taxitis lanceolata* and *Ancimia adiantifolia*.

SOME ADDITIONS TO THE STATE FLORA FROM PUTNAM COUNTY. By LUCIEN M. UNDERWOOD.

While the higher flora of Indiana seems to be fairly well known, it is surprising to find so little on record regarding the lower cryptogams of the state. Except a short paper on "The Mildews of Indiana,"* a few bulletins from the experiment station relating to some injurious fungi, a short list of mosses and lichens from Richmond,† and a few scattering notes in the *Botanical Gazette*, nothing has been placed on record, which, however, is far from saying that nothing has been done in this direction. It is a question whether as teachers of botany we have not swung the pendulum too far in training our students to become expert section-cutters and discriminating histologists and have thereby left out of their course that *cultural* feature of botany that comes only from bringing them in direct contact with nature. I plead for considerable field work as an invaluable adjunct to laboratory instruction. In a year's study of botany a student ought to become fairly proficient in the manipulation of the microscope and at the same time learn how and where plants grow (and especially the less conspicuous plants), and where their position is in the system, thus gaining a love for nature as well as a knowledge of the methods of manipulation. Botany ought to be a *cultural* study as well as a purely *technical* one. When we

J. N. Rose, *Botanical Gazette*, XI, 60-23 (1886).

†Mary P. Haines, 8th, 9th and 10th Ann. Reports, Geol. Survey, 235-239 (1879).

consider the tendency of botanical instruction for the past ten years, it is not surprising that the younger generation of botanists do not know how to collect, and when turned loose in some highly interesting botanical field find, to the sorrow of those who want something of them, that their eyes are trained only for an immersion lens and not at all for learning the richness of the flora about them.

While the season since our advent to the state has been exceedingly dry and therefore unfavorable to the development of fungi, we have in three or four short excursions in the immediate vicinity of Greencastle, secured sufficient material to show a rich cryptogamic flora. A few of the more interesting discoveries will be noted and exhibited:

1. On the sandstone rocks at Fern, a rare moss, *Eustichia Norvegica*, is found in great abundance covering many square rods of the rock wall. It was first reported by Sullivant in 1846 from Lancaster, Ohio, and distributed in his *Musci Alleghanienses* as no. 188. Rau has reported it from Pennsylvania and Mrs. Britton found it in fruit for the first time in the Dalles of the Wisconsin in July, 1883. Its sterile states have been figured by Sullivant* and its fruit by Mrs. Britton†. This Indiana station makes the fourth in the fourth state.

2. On clay banks at Fern we have found a hepatic new to America, *Fossombronia cristata*, Lindb.‡ In Europe it has frequently been confounded with *F. pusilla* and is possibly the plant reported under that name by Sullivant in one of the earlier issues of Gray's Manual. Of the true *pusilla* we have seen no American specimens in fruit, and *Fossombronia* is one of the few genera of the *Jungermaniaceæ* in which the exospore is sufficiently differentiated to furnish satisfactory specific characters. *F. cristata* is easily recognized by the confluent crests of its spores. Its known range hitherto includes Finland, Sweden, Germany, France and England.

3. *Trametes ambigua* (Berk.) Fr. This is not an uncommon species in the vicinity of Greencastle and Fern. It was first described by Berkley§ from specimens collected by Lea in the vicinity of Cincinnati, and has since been reported from Ohio by Morgan, from Kansas by Cragin, and from Missouri by Demetrio, through whom it was distributed by Ellis in N. A. Fungi under the original name *Dædalia ambigua* (no. 1593.)

4. *Hydnum stratosum* Berk. has been found once under a rotten log near

*Mem, Amer. Acad. n. s. III, t. I (1846.)

†Bull. Torrey Bot. Club. X, 99 (1883.)

‡Notiser pro Fauna et Flora Fennica. XIII, 388 (1874).

§*Dædalen ambigua* Berk. Decades of Fungi. n. 83 (1846).

Greencastle. It was first reported from the vicinity of Cincinnati by Lea in 1845,* and afterward by Morgan. We found it in 1889 near Syracuse, N. Y. This makes the third station known to us. The species when fully mature is unlike any other species of *Hydnum* in the stratification of the spines.

5. *Cordyceps capitata* Fr. We have found one specimen of this species in rich woods at Fern. It belongs to a group of fungi that are usually parasites either on living animals like the "caterpillar fungus" of New Zealand, or on living pupæ of insects like *C. militaris*, or on truffles like the present species. This species is usually reported as growing in pine woods, but we found it last year at Cambridge, Mass., growing under oaks on *Elaphomyces granulatus* which is the usual host on which it has been reported from North Carolina by Curties and from New York by Peck. The present specimen seems to be saprophytic, growing from a nidus of decaying matter. It was found of course under deciduous trees.

6. *Phallus Rarenellii* B. & C.† seems to be the common stink-horn of this vicinity. It was originally reported from South Carolina and we found it once at Cambridge, Mass. Under a rotten log at Fern we found its mycelial strands a ramifying network which extended ten feet or more, giving rise to fifteen or twenty fruits in various stages of development. In addition to these fruits there were irregular swellings on the mycelial strands in great abundance; the larger ones were hollow, the smaller solid. They suggest *sclerotia* which so far as we know have never been reported among phalloids. As the specimens were collected in November, it would seem that the plant was making an effort to store up nutriment in these tuber-like bodies for the necessities of the following season.

Besides *Phallus Rarenellii*, which is easily recognized by its rudimentary veil, its thin pileus, and its mild fragrance(?), we have found two other *Phalli* in this vicinity. *P. duplicatus* we have found once. An enormous specimen ten inches in height and with a large bell-like veil fully four inches across is evidently the plant that was referred by Morgan‡ to *P. Daemonum*. That its odor was diabolical we can fully testify. Although Fischer has combined all the indusiate forms with *Phallus duplicatus* and refers then to the genus *Dictyophora*, we have certainly a distinct species in this specimen; whether it should bear the name *P. Daemonum* or not is another question to be settled later.

* loc. cit. n. 86.

†Grevilla, II, 33 (1873). Fischer refers it to *Phyphallus*.

‡Jour. Cin. Soc. Nat. Hist. XI, 115 (1889).

CONNECTING FORMS AMONG THE POLYPOROID FUNGI. By L. M. UNDERWOOD.

UNUSED FOREST RESOURCES. By STANLEY COULTER.

DISTRIBUTION OF CERTAIN FOREST TREES. By STANLEY COULTER.

CLEISTOGAMY IN POLYGONUM. By STANLEY COULTER.

THE CACTUS FLORA OF THE SOUTHWEST. By W. H. EVANS.

DISEASES OF THE SUGAR BEET ROOT. By KATHERINE E. GOLDEN.

In some analyses of sugar beets made at the Purdue Experimenting Station by Prof. Houston, station chemist, the percentage of sugar was so low that an investigation as to the cause was made. Upon a microscopic examination by Dr. Arthur, station botanist, the low per cent. roots were found to have bacteria in them. After that the roots were observed closely, and it was found that individual beets among all the varieties grown were affected, to a greater or less extent, with this bacterial disease.

The roots thus affected do not differ in outward appearance from the healthy roots, but are much lighter in weight. The texture of a healthy root is firm and somewhat brittle, and in color is a clear white, while the diseased root is rather soft and tough and of a yellowish white color. If the diseased root be cut transversely, concentric rings of brownish dots are seen.* These rings are formed by the fibro-vascular bundles, the dots being the separate bundles. The cells of the bundles have a deposition of yellow coloring matter upon their walls, which becomes somewhat darker upon exposure to air.

*Circles of dark dots are found in all sugar beet roots, but in the diseased roots they assume a greater prominence, and thus are very effective in the determination of the disease.

During the early growth of the plants no difference can be seen between the diseased and healthy ones, but as they develop the outer leaves of the diseased plants wither, while the heart leaves curl up much more than the normal, are dull in color, and the under side has a mottled appearance, causing the leaves to resemble somewhat those of the Savoy cabbage. As the season advances the differences between the diseased and healthy plants become more and more accentuated. In the early season the bacteria are found in parts of the plant only, but that may be any part from the leaves to the extreme end of the tap root; on account of this it is difficult to surmise how the plants become diseased. In the late season the bacteria are found permeating every part of the plant.

Examined microscopically the bacteria are found to the greatest extent in the parenchymatous tissue, but the tissue is not broken down by them. They are found imbedded in the substance of the protoplasm as well as being in the cell sap.

In form the beet bacterium is shortly cylindrical, being about twice as long as broad. They occur mainly as isolated cells, though they are sometimes found in pairs. When vegetating rapidly the bacteria are very active, moving in and out among one another with great rapidity. From their arthrosporous character the bacteria of the sugar beet very probably belong to the genus *Bacterium*.

The pure germ is easily obtained by the ordinary gelatine or agar plate separation method, if a piece of the root that has no contact with the surface be used for inoculation. This gives the disease germ only, free from soil and air contamination.

Very good development of the bacterium has been obtained by test tube cultures of acid and neutral nutrient gelatine. Upon acid gelatine, using spot cultures, the bacterium forms round, irregular-edged, greyish-yellow masses, having beautiful iridescent surfaces. This iridescence is a peculiar characteristic of the organism grown upon solid acid media. The masses retain this iridescence for about two weeks; then the surfaces become crust-like and dry, and the masses decidedly yellow in color. The bacteria liquefy the gelatine, gradually forming hemispherical depressions into which they drop. In neutral gelatine cultures they form, in most respects, the same kind of growth as in acid, but the surface has simply a shiny appearance, and as the masses age they do not form crust-like surfaces. They liquefy the neutral gelatine much more rapidly than the acid.

A curious feature of this organism is that it causes the gelatine to become

distinctly alkaline, even though it be acid before the organism has grown on it. The diseased beet roots give a neutral or very slightly acid reaction.

In a Pasteur sugar culture the bacteria grow well, causing the liquid to become slightly turbid in 24 hours. As growth goes on, the turbidity becomes greater, and again decreases until at the end of nine or ten days, when the growth practically ceases, the liquid becomes clear, the bacteria forming a greyish yellow sediment in the bottom of the tube.

They also develop well in sterilized sugar beet juice, but as contact with the air causes the juice to turn black, they are not readily seen. In juice that had been cleared by filtering through bone black very poor growths were obtained.

Inoculation tests were made upon six apparently healthy roots that were brought from the garden into the greenhouse. Four of these now give indications of having the disease; the leaves are crinkled, the under side being dull and mottled in appearance. Bacteria were found in the leaves and petioles.

Considerable interest attaches to this disease from its reduction of the sugar content of the root, and its prevalence throughout the state. The study of the subject was begun too late to estimate the loss by the disease, but as was already mentioned, diseased plants were found among all the beets grown on the station grounds, which included eight varieties for the past year—Red Top sugar, Silesian sugar, Imperial sugar, Dippe's Vilmorin, Simon LeGrand improved white, Dippe's Kleiwanzleben, Flormond Desprez richest, and Bultean Desprez richest. Roots were sent to the station for analysis from twenty-seven different places in the state and from nineteen of these some of the roots were diseased. This is not a fair estimate of the prevalence of the disease, however, as the tendency is, in sending beets for analysis, to choose the best looking and most nearly perfect ones, and the proportion of infected specimens included is necessarily much short of the actual average.

There were more of the Kleiwanzleben and Vilmorin beets sent than of the other varieties, and these gave respectively 12.9 per cent. and 12.7 per cent. diseased roots. Counting all the varieties there were 434 beets sent, among which were 12.1 per cent. diseased. In analyzing for the sugar content one set gave 13.3 per cent for good beets, 11.9 per cent. for beets showing a trace of the disease; another set gave 10.2 per cent. for good ones, 7 per cent. for diseased ones; while still another set, that Prof. Huston thinks gives the fairest estimate of loss, gave 10.3 per cent. for good beets, and 5.7

per cent. for diseased ones, a loss of nearly 50 per cent. of the sugar content. The per cent. of sugar is expressed in terms of the beet, not of the juice.

Besides the bacterial disease that is general for all parts of the plant, the sugar beet roots are affected with diseases of a local character. These are in the form of surface scabs, discoloration of the tissue, and small masses of tissue different from that surrounding them.

The scabs are of two kinds, one resembling the so-called "deep scab" of potatoes, while the other protrudes from the surface.

The deep scabs are light brown in color when first affecting the root, but as the root is more deeply affected they become dark brown or rusty black. They vary in size from a mere dot to an extent sufficient to nearly cover the whole root, though the latter case is not so often found. The deep scabs are sometimes accompanied by a red discoloration of the tissue that, in some cases, extends fully two inches beneath the surface. Upon exposure to the air the red color changes to magenta. These scabs are not to be confounded with the breaks in the surface of the roots caused by uneven growth.

The raised scab differs essentially from the preceding in outward appearance, as it forms warty elevations on the surface of the roots. It has the same general color as the deep scabs, but has not been found covering so great an extent of surface as they. When found in large quantity, instead of extending itself over the surface, it seems to have a tendency to form bands encircling the root. It is oftenest found near the neck of the beet at or near the surface of the ground. Both forms of scab are found on the same root, sometimes in close proximity, and forms have been found seemingly intermediate between the two. It is probable that the two forms of scab are just different stages of the same disease; the raised scab being the first stage, where the irritated tissue with the corky modifications form elevations on the surface of the root; as the tissue outside the corky layers dies and is gradually eliminated, the depressions are left in the surface. This theory is given further force from the fact that the same organism has been obtained from plate cultures of both forms of scab. The organism has the characteristic of the potato scab germ described by Dr. Thaxter.* There are the same filamentous forms that break up into bacteria-like bodies, and the dark stain given to the culture medium.

The organism itself is perfectly colorless, but it excretes a substance

*Annual Report Conn. Agr. Exp. Sta., 1890, pp. 81-95.

which in the presence of oxygen becomes dark brown. Cultures have been made in the fermentation tubes brought out by Dr. Theobald Smith, which are so constructed that one arm of the tube remains free of all gases. In such a tube the part of the culture in contact with the air becomes a deep brown color and that in the opposite gas-free portion remains uncolored for even a month or more, and its final change to brown, if the culture be continued sufficiently long, is without doubt due to diffusion, both of the gas absorbed from the air and the oxydized substance, by which they pass from the open arm of the tube into the closed arm.

Prof. Bolley* has induced the scab on the sugar beets by inoculating with the organism from potato scab. The scab has also been transmitted to the beet directly from the potato, and also from soil in which potatoes affected with scab had been grown, by experiments made in a cool greenhouse at the Purdue station. In the former case a young potato tuber, just removed from a pot-grown plant and well covered with active scab, was laid in contact with a perfectly healthy root of a young beet. An examination was made eight days later, but with no distinct evidence of results. A further examination thirty-seven days later showed a well defined scab about a quarter of an inch across upon the beet, where the diseased potato touched it, and no trace of scab elsewhere. In the latter case ten healthy beets were transplanted to pots containing soil in which potatoes affected with the scab had been grown. These were examined sixty-four days after being transplanted, and eight of the ten roots were affected with the scab, five of them having the neck entirely surrounded with it.

The scabbing originates without doubt from the soil. How long the organism may maintain itself in the soil as a saprophyte is uncertain, but the data elicited by Professor Bolley and by the Purdue station appears to show that the time may extend over one or two years.

The tissue of the roots is found to be blackened occasionally. This blackening is in the parenchymatous tissues between the rings of fibro-vascular bundles, and is of varying extent. It is sometimes found in roots that are neither affected with the bacterial disease nor scab.

There also occur small spherical or spheroidal masses that differ from the rest of the interior tissue of the roots in having a uniform watery appearance, similar to that of a water-core apple, and may, for the sake of distinction, be called water-core spots. They occur in the parenchymatous tissue, and are sharply defined, not grading into the adjoining tissue.

Bulletin N. Dakota Exper. Sta., No. 4, December, 1891.

They are colorless, or of a pale yellowish tint, and turn black upon immersion in alcohol, the rest of the beet remaining colorless. The spots are composed entirely of parenchyma tissue, the cells having fine delicate walls. The cells, in the specimens examined, measured .03 to .075 mm. in diameter, while the cells of the adjoining parenchyma measured .15 to .25 mm. in diameter. The measurements were taken in transverse sections of the root. No parasitic organism, either animal or vegetable, was found associated with them, and no explanation of their presence is known.

The scabs, discoloration, and water-core spots do not seem to affect the size of the beets, as they are oftener found in medium and large beets than in smaller ones. The effect of their influence on the sugar content is not known.

PLANT ZONES OF ARIZONA. By D. T. McDOUGAL.

[ABSTRACT.]

The author, while collecting plants in Arizona during May to October, 1891, for the Botanical Division of the U. S. Department of Agriculture, made a series of observations resulting in additional data on a biological survey of the San Francisco Mountains made by Dr. C. H. Merriam in the previous year.

The feasibility of the correlation of the life forms of this region into the Alpine, Timberline, Hudsonian, Canadian, Pine, Piñon and Desert Zones was recognized. Detailed notes of the occurrence of plants peculiar to each zone were made, and the bounding lines of each were carried southward through the Mogollon, Graham and Chiricahua mountains, and over the edge of the Colorado Plateau into the Verdi Touti, Salt and Gila basins to the Mexican boundary.

RELATION OF AVAILABLE ENZYM IN THE SEED TO GROWTH OF THE PLANT. By J. C. ARTHUR.

THE POTATO TUBER AS A MEANS OF TRANSMITTING ENERGY. By J. C. ARTHUR

SCIENCE AND THE COLUMBIAN EXPOSITION. By J. L. CAMPBELL.

[ABSTRACT.]

In this paper the author discussed the relation of science to the Exposition of 1893, the subject being limited to the *classification* and the *awards*.

The suggestions presented were based chiefly on the writer's knowledge of the subject from his experience as Secretary of the Centennial Exhibition, 1876.

RECENT ARCHÆOLOGICAL DISCOVERIES IN SOUTHERN OHIO. By WARREN K. MOOREHEAD.

METHODS OBSERVED IN ARCHÆOLOGICAL RESEARCH. By WARREN K. MOOREHEAD.

THE PRE-HISTORIC EARTHWORKS OF HENRY COUNTY, IND. By T. B. REDDING.

The mounds and enclosures of this county are not so large as some of those of Madison, Randolph and Wayne counties adjoining us, but are large enough and numerous enough to be of interest. While but very recently reclaimed from the wilderness and from savage life, Henry county has its antiquities; an unwritten history, a history full of human life, human joys and human sufferings; of organized and aggregated labor; of war, battle and bloodshed; of passions and worship. But the joys, the sorrows, the loves, the hates, the struggles and the triumphs of those long centuries past have faded forever out of sight, except so far as preserved in these ancient and rude earth works. Since they lived, thought and acted—

“Year after year its course has sped;
Age after age has passed away.
And generations born and dead
Have mingled with their kindred clay.”

—Finley.

So far as my knowledge extends there are twenty artificial mounds and fourteen enclosures within the limits of Henry county. There are also certain mounds or elevations that have much the appearance of artificial mounds, but of which I am not sure, numbering in all twelve to fourteen,

and one uncertain enclosure. Of these the strong probability is some are artificial. Doubtless some of the smaller mounds and enclosures have long since been obliterated by cultivation.

I will now give a detailed list of the mounds and enclosures of Henry county, which I have represented upon an outline map. There is a circular earthwork, or enclosure, on E. S. E. Section 1, T. 16, R. 10, in Franklin township, owned by J. P. Nicholson, about sixty rods east of the pike. This has been almost obliterated by long cultivation. It is about 150 feet in diameter. I got my information mainly from Jethro Wickersham, whose father once owned the farm. There is a circular inclosure on the line between the N. E. and N. W. quarters of Sec. 22, T. 17, R. 10, Henry township, 100 rods west, and one and three-eighths of a mile south of the court house, on lands owned by R. M. Chambers and M. L. Bundy. It is still in the woods though mostly cut off. Its diameter (measuring in all cases from the center of the embankments), is 115 feet; the height of embankment, at highest point from bottom of ditch is about three feet. There is an open place, or gateway, on the east side, about twelve feet wide. There is the appearance of a small mound inside of the enclosure toward the west side, about fifteen feet in diameter and eighteen to twenty-four inches high. Width of ditch about eight feet, of embankment about fifteen feet. Large trees have grown, died and decayed within this enclosure and its ditches and upon its embankments since it was built. There is also a small mound in S. W. quarter Sec. 7, T. 16, R. 11 E., nearly obliterated by cultivation, but I have not made a personal inspection of it. There is another enclosure about 250 feet in diameter on the west side of the N. E. quarter of S. W. quarter Sec. 2, T. 17, R. 10, owned by Joseph Dorran. In early times this enclosure was a noted structure. Its banks were five or six feet high, and the ditches were clearly marked, but the northern turnpike runs through the eastern side of it, while the larger part of it has been under cultivation for more than fifty years, and it is gradually being obliterated. Its banks are now not more than one to two feet high. I will say here, that in all the enclosures in this county the ditches are on the inside of the enclosure. On the northeast quarter of this same section, mostly on the southwest quarter of the quarter and less than half a mile to the northeast from the above named enclosure, is the largest group of enclosures and mounds found in the county. They are situated on the eastern part of the farm of John C. Hudson, and cover an area of ten to twenty acres. There are in the group nine well defined enclosures, and one or two apparent enclosures which

have been so completely obliterated by the plow that I cannot be certain about them. I have visited and measured all of these. The largest is situated farthest east, near the line and very near the N. E. corner of the quarter quarter. It is 650 feet in circumference and is an ellipse, longest east and west. Its east and west diameter is 215 feet. The north and south is about 150 feet. Within this enclosure is a large mound, longest east and west and having much the appearance of two mounds joined to each other, the western mound being the highest. The length of the mound, east and west, is 140 feet and it is about 100 feet wide, north and south. The height of the mounds above the general original surface is about ten feet; above the bottom of the ditches about fifteen feet. The ditch varies in depth but is probably six feet in deepest place, and shallows off into three feet at places. It is mostly in the original forest, but has its south embankment in a cultivated field. On each side of the eastern part of the mound there are slight elevations, whether natural or artificial I cannot tell. They give the mound an appearance of an attempt to imitate a cross. I have a map of this whole group, and an elevation showing shape of the large mound. This mound has been dug into in four or five places at different times.

In the fall of 1890 myself and several others made an exploration of parts of this mound. We dug a trench six to eight feet deep from the east side to the center, and one from north to south through the western end of the mound. We found two places in the last, one within eight or ten feet of each end, where the clay had been burned hard, and yet there were no ashes. Between these two places about thirty feet apart we found deposits of ashes but no burnt clay, indicating that the ashes had been removed from the places of fire and thrown in heaps at a distance of a few feet. These places of burnt earth were about two by three feet in size and burned to the depth of ten or more inches. One of them had the appearance of having been raised above the surrounding earth seven or more inches. It was longest east and west and had somewhat the appearance of the figure 8. Near the center of the mound in the trench dug from the eastern side we found, at a depth of nearly nine feet, a large bed of ashes some six by seven feet in diameter. The bed was slightly hollowed out and the ashes at deepest place, near the center, were not less than four to five inches in depth. Among these ashes we found much charcoal and many fragments of bones, some of which I have with me. I am not able to say from what animal they are. A little to the northwest of

this bed of ashes was another bed of ashes and burnt clay which had been explored at some time by other parties, but I cannot give results. The large bed found by us was burned hard, of a dull red color, to a depth of about eight inches.

At the time of making the explorations of the large mound we discovered another small mound about sixty rods to the northeast of the large one, 100 feet in diameter and about six feet high, situated upon a point of a hill overlooking Blue river valley, and in front of which was formerly a marsh of several acres. The ditch and enclosure around the mound are very distinct, it having only very recently been cleared of timber. The ditch at places is three feet deep and the embankment averages about two and a half feet in height.

To the east of this a few rods, just across a deep ravine on the north edge of a hill, is an embankment of about six feet in height and nearly two hundred feet long. To the south of the ditch behind the embankment, which is not less than forty to fifty feet wide, the hill rises about twenty feet. The excavation behind embankment is longest east and west. It is wholly unlike anything else found in the county, and no one is able to give any account of its origin.

Ten rods west of this large mound and enclosure is another enclosure, partly in the woods but mostly in the cultivated field. The ditch is well preserved in that part in the woods, but is almost wholly obliterated in that part within the field. As near as I could determine this enclosure was about one hundred and fifty feet in diameter. The ditch on the north side is now about two to two and one-half feet in depth. I am inclined to the opinion that there was also a mound probably two or three feet high within its enclosure, but if so it is nearly levelled. One hundred feet to the northwest of the last is another enclosure, all in the woods, ninety-four feet in diameter and with shallow inside ditches at present one to three feet deep, and having a gateway on east, opening toward the large mound already described. Near the gateway, on the south, is the appearance of a small mound about twelve feet in diameter and twelve to eighteen inches high. It has been dug into recently and seems to be a mass of gravel. I am in doubt whether it is natural or artificial. One hundred feet from the last is an artificial mound forty feet in diameter and about six feet high. The south edge is in the cultivated field but the main body of the mound is in the woods. It has been recently dug into by Joshua Holland, of North Carolina, and Mr. Reynolds, of the Smithsonian Institute,

but work was not completed and nothing of importance was found. This is the only clearly identified mound in the whole group not within a circular enclosure. About one hundred and fifty feet south of this little mound, within the cultivated field, are the remains of a large circular enclosure with a gateway facing the east and the large enclosure already described. It is two hundred and fifty feet in diameter and the ditches are from three to five feet or more in depth, notwithstanding years of cultivation under the plow. There is the appearance of a mound in the western part of this enclosure, about forty feet in diameter and about two feet high.

One hundred feet south of the above is another enclosure one hundred and fifty feet in diameter, with ditches two or three feet in depth. It has also an opening to the east, but not so well marked as the others. This enclosure is almost immediately east of the house on said tract and just east of the old orchard. A long period of cultivation has doubtless much lowered its walls. There is a slight indication of a mound near by, but if it is one the plow has so completely obscured the evidences that it is not safe to call it one. About two hundred and fifty feet to the southeast, in the edge of the grove, is another enclosure one hundred feet in diameter, with ditch on inside two to two and one-half feet in depth. It has also a gate or opening on the east facing the large enclosed mound. Sixty feet to the southeast of the above is another enclosure ninety feet in diameter, with inside ditch eighteen to twenty-four inches in depth, and having an opening to the northeast facing the large enclosure and mound. There is also a small mound in the center of this enclosure.

Going another hundred feet to the southeast we find another enclosure one hundred and twenty feet in diameter, with a mound in the center from three to five feet high. The ditch is from two to three feet deep. There is an opening on the northeast facing the large enclosure and mound. East, slightly north of the above and adjoining it is another enclosure one hundred feet in diameter. The ditch is shallow, not more than eighteen to twenty-four inches in depth. The embankment on the west and adjoining the preceding seems to be common to both enclosures. The space between the ditches of the two is about twenty to twenty-five feet. To the northeast is a low, wet place. The opening is not very clearly marked in this last enclosure but it seems to be to the east. North of this last, about three hundred feet in the cultivated field, are very strong evidences of another enclosure, but it has been so disfigured by the plow and long cultivation that I do not feel safe in saying positively that it is an artificial enclosure,

but it is very suggestive of one, and is about one hundred and sixty feet in diameter.

There are three or four other little hillocks in the neighborhood of these enclosures that look much like small mounds. On the west side of the pike, about sixty or seventy rods west of the large mound, is a gravel bank in which a number of human skeletons have been found. There was found in this bank, recently, the skeleton of a dog, about six feet below the surface. Skeletons have been found both in a horizontal and in an erect posture. In it are also found pieces of charcoal; also shafts of earth and clay. These are round and from five to eight feet deep and two or three feet in diameter, as if a grave had been dug and then filled with earth. It is probable that there was a mound on this bank, but it has been so long worked and so much of it removed that it cannot be verified. It was at least a burial ground. The skeletons mostly crumble on being exposed.

Across the river, about a mile to the west, on the N half of Sec. 3, T. 17, R. 10, belonging, also, to Mr. Hudleson, is another large circular enclosure in cultivated ground. It is probably 150 feet in diameter, and before the land was cleared was enclosed by embankments five to six feet high,—but a long period of cultivation has nearly obliterated the embankments. I do not know whether it enclosed a mound or not, but probably did. There was, until recently, a mound on S. W. S. E. quarter Sec. 1, T. 17, R. 10, owned by Joseph Smith, about thirty rods west of his house. It was about fifty feet in diameter, and eight to ten feet high, before cultivation. During the last year Mr. Smith plowed it down and used the earth to make an embankment along the creek near by. He tells me that he came to a bed of ashes and charcoal in the center of the mound, about six feet square but did not examine to ascertain the depth. He did not notice any fragments of bones or other articles.

There is also a mound on the E. S. E. quarter Sec. 24, T. 16, R. 10, in Franklin township, now owned by John Gilbert. It is small, probably forty feet in diameter, and three or four feet high. There is another mound in the same township on S. W. S. W. quarter Sec. 15, T. 16, R. 10, owned by Charles Stubbs. It is about three feet high and fifty feet in diameter. It has been dug into and ashes and coals found. Another mound, in this township, is found on S. W. S. E. quarter Sec. 28, T. 16, R. 11, owned by D. H. Fenstamaker, about thirty rods south of the Central railroad, about six feet high and seventy-five across, before plowed down. There is a small hillock, or mound, in the southeast corner of the county, about ten feet

high and fifty in diameter, on the top of which formerly grew a large beech tree. It is supposed, by some, to be artificial, but others think it natural. I have not examined it. It is in the N. E. quarter Sec. 31, T. 16, R. 12. There is a small mound, now almost obliterated, on the N. W. S. E. quarter Sec. 14, T. 16, R. 9, owned by Daniel Jackson. Was probably twenty-five feet in diameter and four feet high. Was dug into and ashes and coals found. About a mile southwest of the above, on the S. W. quarter Sec. 3, T. 16, R. 9, owned by John Small, is another small mound of about the same size of the one just described.

On Charles McDormain's farm near the S. E. cor. of Sec. 20, T. 17, R. 10, is a mound about fifty feet in diameter and three feet high. It has been under cultivation for more than fifty years, and was, originally, probably over six feet high. It has been dug into. Flints, ashes and coals were found. On the Hoover place, west of the barn, in the N. E. quarter Sec. 5, T. 16, R. 10, is a small mound, now about fifty feet in diameter and two feet high. It has been plowed over fifty years or more. There is a small mound on the farm of Jonathan K. Bond, on the N. W. S. W., quarter Sec. 24, T. 17, R. 9, probably forty feet in diameter and four feet high. This, and the one on McDorman's farm, and the large circular enclosure on the west part of Hudleson's farm and a small mound on Benj. Wilhoit's farm are the only artificial earthworks of which I have any information, which are located on the west side of Blue River, in this county. There is a small mound on S. E. N. E. quarter Sec. 28, T. 16, R. 10, in Spiceland township, on the farm owned by Hinshaw's heirs. It is represented as about fifty feet across and three or four high. It was dug into, a few years ago, and ashes and coals found.

One of the largest and best preserved mounds is found on N. E. S. E. quarter Sec. 26, T. 17, R. 10, owned by John R. Peed, about two and a half miles southeast of New Castle. Until recently it was in a forest, but has been cleared, and, the embankments plowed down and the ditches partly filled. It is sixty-five feet in diameter, and at least six feet high. The ditches were formerly about three feet deep. I first saw this mound when I was a small boy, it being near the farm on which I was brought up, and was often visited by me. When I first saw it, there was growing on its top a large red oak three feet in diameter. The mound has been dug into several times. Ashes, coals, bones and fragments of pottery were found, but they have been scattered and carried off, and I cannot find any of them to examine. I have recently visited the mound. It is surrounded by an enclosure

130 feet in diameter from the crest of the embankment on one side to that on the other. The mound is situated in western part of the enclosure, fifty feet west of the eastern side. There is a gate, or opening in the eastern wall. The mound is at least six feet high above the general level of country, and was about nine feet above bottom of the ditches when I first saw it. The old red oak has blown down, but the stump is still lying on the mound. At the ground it is about five feet through, and, as near as I could calculate from the annual rings of growth, it was at least 280 years old. There is, also, a small mound on the S. N. W. quarter Sec. 18, T. 16, R. 12, owned by J. V. Huffman and now occupied as a cemetery. It is about seventy feet in diameter and was formerly eight to ten feet high, and is now about six feet in height. It was dug into a number of years ago and ashes, coals and burned stones were found. Near by, about 150 feet to the Northwest is a pit from which the earth was probably taken to build the mound.

Daniel Harvey informs me that there are three small mounds on N. W. N. W. quarter Sec. 36, T. 18, R. 10, now owned by Thomas Graham, arranged in a crescent shape. The large mound occupies the center and two small mounds the ends. The center mound was dug into about thirty years ago by Mr. Harvey and others, but found no skeletons nor remains. The central mound is about ten feet high and sixty feet in diameter, and the outside mounds are about thirty feet in diameter and four or five feet high, so Daniel Harvey tells me. H. B. Hernly informs me that there is a large mound on W. N. W. quarter Sec. 25, T. 18, R. 10, owned by him. It has not been explored and may or may not be artificial. I have had no opportunity to examine it. There is a mound five or six feet high and twenty five to forty feet in diameter on the N. E. N. E. quarter Sec. 27, T. 18, R. 10, now owned by Benj. Wilhoit. It has been dug into and shells, etc., found.

The graves of a departed race are found in a great many of the gravel banks of the country. I have the skulls and some of the other bones, and a lot of beads, pendants, gorgets, and other articles, taken from some of these graves upon John Hosea's farm, formerly owned by my father, near this city. These pendants, gorgets and beads are mostly made from the shell of a kind of Conch, called *Busycon perversum*, found along the Atlantic coast from Massachusetts south to the Gulf of Mexico. Some are from other kinds of shells found along the same coast. Whether these are the remains of the Mound-builders, or of a later race, is unknown. They

are very similar to many of the articles found in the mounds in such position as to lead to the supposition that they were placed there by the builders of the mounds.

ON LECONTE'S TERRAPINS, *EMYS CONCINNA* AND *E. FLORIDANA*. By O. P. HAY.

ON THE BREEDING HABITS, EGGS, AND YOUNG OF CERTAIN SNAKES. By O. P. HAY.

Notwithstanding the deep impression which serpents have made on the human mind, as shown in literature and in popular conversation, it is surprising how little accurate information has been accumulated concerning some of their habits. The densest ignorance, the result of inattention and general lack of interest, prevails with regard to some of the most interesting matters connected with the life-history of snakes; while on the other hand, many of the popular notions about the powers of these animals are either wholly false or are gross exaggerations of the truth. The breeding habits of our snakes, even of the most common species, belong among the things about which little is known. Even our biologists have given but little attention to this subject, while unscientific people simply recognize the fact that nests of snake eggs are occasionally met with. For instance, who would not suppose that all the essential facts are known concerning the reproduction of the common black-racer, *Bascanion constrictor*? Nevertheless, where have we been told when it lays its eggs, how many there are of them, how they are concealed, and when they hatch?

Some snakes are known to lay eggs which after a period produce young. Other snakes are known to retain the eggs within the body until the young have attained sufficient size and strength to care for themselves after birth. Still other species are supposed sometimes to lay eggs, at other times to bring forth living young,* or to produce some eggs and some living young at the same time.† There are, indeed, oviparous snakes and snakes which are ovoviviparous, and there is a conspicuous difference in their eggs. The eggs of the oviparous species are furnished with a thick, tough, flexible covering, or "shell," while the eggs of the species which produce living

* Proc. A. A. A. S., 1873, p. 185.

† Proc. Phil. Acad. Sci., 1887, p. 121.

young have coverings which are very thin and delicate. Now, should such eggs as the latter be laid any considerable period before the young are ready to be excluded, the thin envelopes would surely be torn during the writhings of the embryo. That some of the eggs may be only partially developed at the time when the embryos of other eggs are ready to be ushered into the world, and that all may be expelled together, is possible; but this is not the normal course of things and may not be well for the immature young. Normally the coverings of such eggs are ruptured before birth or immediately afterwards. On the other hand, it is quite probable that the eggs of the oviparous species are laid a considerable period before they are hatched. The tough coverings of such eggs protect them from attacks and injuries from without, and at the same time resist the movements of the young snake within. So far as we know, these eggs are deposited in the earth, in piles of decaying vegetable matter, and similar places.

A very curious structure deserves mention here. This is the "egg-tooth," a small tooth fixed to the united premaxillary bones and projecting forward slightly beyond the edge of the upper lip. It is present only in the embryo, and is shed very shortly after the escape of the young snake from the egg. In the ovoviviparous species, the tooth may apparently be shed before the young are born. The tooth is employed by the little snake in ripping open the tough egg-covering in its efforts to escape from its prison. It would appear to be of little service to the young which are mature when born, since the egg-coverings are so very tender; nevertheless, I have found the tooth present in all of the ovoviviparous species whose young I have had opportunity to study. This tooth, as found in the black-racer, was described as long ago as 1857, by Dr. Weinland;* but Müller had observed it even earlier.

The Crotalidae, including the rattlesnake, the copperhead, and the water-moccasin, all, so far as I am able to discover, bring forth living young. The number produced at each birth is small as compared with the number of young sent into the world by some other species.

As to the breeding habits of the copperhead, *Agkistrodon contortrix*, we have the statement of Dr. J. A. Allen† that in Massachusetts five out of seven females caught in the latter part of July contained slightly developed embryos, while of six killed in September, the oviducts of each contained from seven to nine young, each of which had a length of six inches. As to

* Proc. Essex Institute, Vol. II, p. 28, pl. I.

† Proc. Bost. Soc. Nat. Hist., 1868, Vol. XII, p. 179.

the time of the pairing of the sexes, I have knowledge of only one observation. My friend, Rev. A. M. Hall, brought me from Western Pennsylvania two specimens of this species, which he took while pairing, on the 28th of August. Unfortunately, the female was disposed of before my investigation of this subject was begun. This observation and those of Dr. Allen, when considered together, seem to indicate a period of gestation of nearly a year.

The breeding habits of the water-moccasin, *Agkistrodon piscivorus*, are no doubt much like those of the copperhead. A female 26 inches long (U. S. Nat. Mus., No. 17968), which was taken on the Arkansas bank of the Mississippi river, just opposite Memphis, in the latter days of June, contains seven eggs, four of which are in the left oviduct. Usually the larger number of eggs in snakes is found in the right oviduct. The eggs of this specimen are about the size of the yolk of a hen's egg. In each is an embryo not larger than a common pea.

The breeding habits of *Crotalus* do not appear to be well known. Prof. Putnam* dissected a female which he says contained in the oviducts eight fully formed eggs, besides a number of smaller ones, which he supposed belonged to a later brood. It is more probable that all the eggs were really in the ovaries. A female rattlesnake, 39 inches long (U. S. Nat. Mus., No. 17959), was brought to me from Western Pennsylvania by Mr. Hall. In this I find nine eggs, four of which are in the left oviduct. The eggs will average nearly an inch and a half in long, and an inch in short, diameter. In one of them I find an embryo about 3 inches long. The egg-coverings are extremely thin. The mother snake was captured some time in August, probably before the 15th. At what time of year the sexes unite I find nothing on record. Prof. S. W. Williston, who has had abundant opportunities for making observations on *C. confluentus*, states† that the sexes pair in May. Nor do I know how large the young are at the time of their birth. M. Palisot Beauvois, as quoted by Dr. Goode,‡ says that he saw five young run into the mouth of a mother snake, and that these young were about the size of a goose quill. The young are undoubtedly much larger than this statement makes them. There is apparently as strong a tendency in observers to minify the size of the young of snakes as there is to magnify the size of the adults.

* Amer. Nat., Vol. II, p. 133.

† Amer. Nat., Vol. XII, p. 207.

‡ Proc. A. A. A. S., 1873, p. 183.

I have been enabled to make some observations on *Sistrurus catenatus* Raf. (*Crotalus tergeminus* Say.). In the American Naturalist for March, 1887, pp. 211-218, I published some notes on the breeding habits and young of this species. About September 1, two females, which had been kept in confinement, brought forth young, one six, the other seven. The young were not seen by myself at the time of birth, but on the 1st of January they were at least 10 inches long. From a female sent me from Paris, Ill., I have taken an almost fully developed embryo (U. S. Nat. Mus., No. 17947). It measures $7\frac{1}{2}$ inches in length, and this is probably nearly the length which it would have been when born. A considerable amount of the yolk was still spread over and among the coils of the little snake; but, when its body was opened, a large mass of the yolk was seen to have been received within its walls. This would be sufficient to maintain life and growth until the little reptile could provide for its own necessities. The fang is developed, and the egg-tooth is present, although it does not seem to be directed so much forward as in other species. In the oviduct, lying alongside of the embryo just described, was another egg which contained an embryo only about 4 inches in length. It was so deeply immersed in the yolk that its presence was not suspected until the yolk was cut partially away. Nevertheless this immature little snake exhibits quite distinctly the pattern of coloration found in the adults. In contact with this egg was another in which no indications of an embryo were to be found. The more immature young were probably lying farther forward in the animal, but of this I am not now certain. Should all these eggs be expelled from the mother's body at the same time, it would seem that the least developed young must perish. A female (U. S. Nat. Mus., No. 17950) of this species taken in Hamilton county, Ind., contained eight eggs, and these had not yet left the ovaries. Three of the eggs were in the left ovary. The eggs were an inch long by half an inch in the short diameter. Prof. Putnam mentions* a specimen of *Sistrurus miliarius* which contained fourteen eggs. This appears to be a larger number than is usually found in the *Crotalidæ*.

The species of the genus *Eutainia* are probably all ovoviviparous. Dr. Goode, as already cited, says that there is some reason to believe that some of them are in some instances oviparous, in others ovoviviparous. Dr. C. C. Abbott† says that the eggs of the garter-snake, *E. sirtalis*, and of the rib-

* Amer. Nat., Vol. II, p. 134.

† Rambles, &c., p. 295.

bon snake, *E. saurita*, are deposited in the loose sandy soil of the recently plowed fields. He has found none earlier than May 9; and once he found a complement of seventeen within a day or two of hatching. He farther states that he has never come across a young snake less than four inches in length, except in the case of the hog-nosed snake *Heterodon platirhinos*. I am convinced that there is some error of observation here. I shall present evidence that the species of *Eutainia* bring forth living young, and that too rather late in the summer and in autumn. It seems improbable that a snake should usually be ovoviviparous, and again, at rare times, should lay eggs furnished with coverings suitable for protecting the developing embryos. If, notwithstanding all this, the *Eutainias* do lay spring eggs, I shall be extremely glad to receive a batch of them.

Dr. H. C. Bumpus, in his interesting account of the snakes,* says that the eggs of *Eutainia sirtalis* and of *E. saurita* are sometimes found about out-buildings, and in hatching give birth to little fellows having enormous eyes and a spotted body, the longitudinal bands of the adults only being gained after several sloughings of the skin. The source of the information here detailed is not given; but almost certainly the eggs of some other species have been mistaken for those of *Eutainia*. Young of both the species, especially those of *saurita*, taken by myself from the oviducts of the female and with a considerable portion of the yolk still unabsorbed, have the stripes perfectly distinct.

As to *E. sirtalis*, Prof. F. W. Putnam† states that a female taken July 22, contained forty-two nearly developed young. Each of these was 5½ inches long. The mother snake was 35 inches long. Dr. J. Schneck, of Mt. Carmel, Ill., writes‡ that seventy-eight were taken from a female. He implies that he saw this done. C. Few Seiss says§ that the sexes of this species copulate in early spring and produce from thirteen to eighty young. That he has seen the latter number from a single snake he does not say. Drs. Coues and Yarrow refer|| to the habits of *Eutainia sirtalis parietalis*, as observed by them in Montana during the month of August. "At this season all the female individuals observed were gravid with nearly matured embryos. Like others of the genus, this species is ovoviviparous, the young being some 6 inches in length when born." In a specimen of *E.*

* Riverside Natural History, Vol. III, p. 371.

† Amer. Nat., Vol. II, p. 134.

‡ Amer. Nat., Vol. XVI, p. 1008.

§ Scientific Amer., Vol. LXIII, p. 105.

|| Bulletin U. S. Geol. & Geo. Survey, Vol. IV, p. 277.

sirtalis (U. S. Nat. Mus., No. 17960), captured near the city of Indianapolis by Dr. Alex. Jameson about August 1, I find thirty-nine partially developed young. Of these, twenty-five are in the right uterus. The young measure 6 inches in length. There is a considerable amount of yolk still remaining attached to these young, a fact which indicates that they will increase in size before birth. An examination of the mouth of some of these little snakes shows that the egg-tooth is present. The membrane which surrounds each egg is quite thin. The female bearing this lot of young is 33 inches in length. Another female (U. S. Nat. Mus., No. 17961), from Paris, Ill., of nearly the same size, contained about thirty-five young snakes, these being packed together so densely in the mother's body that it was difficult to determine the number accurately without removing them. They are each 7 inches long, and are evidently just ready to be expelled. An examination of about half a dozen of them failed to reveal the presence of the egg-tooth, which has therefore been shed. Nor could I determine with certainty that any egg-covering was present. The yolk of the egg, also, is wholly consumed. On opening these young snakes I find little or none of the yolk within the body. In this respect they contrast strongly with the young of the rattlesnakes. The young garter-snakes must from the first depend on their own activities for support. This accords well with the report of Mr. C. Few Seiss, that the young of a female kept in confinement began to feed shortly after birth, struggling vigorously with one another for the earthworms thrown them. At what time during the summer the Paris, Ill., specimen was captured I do not know. Seiss' statement that the sexes of *E. sirtalis* pair in the early spring has already been mentioned. Drs. Coues and Yarrow (*op. cit.*, p. 278) tell us that the females of the closely related species, *E. radix*, are pregnant in July and August, bringing forth as many as thirty to forty young; and that they are found in *coitu* in September and October. Can it be that snakes copulate twice in the year, as Agassiz says* some turtles do, and as Gage has recently found† to be the habit of the newt, *Diemyctylus*? Observations on this point are to be desired.

The ribbon-snake, *E. saurita*, appears to be wholly similar in its breeding habits to its relative just considered, although it probably does not bring forth so many young at each birth. Prof. Putnam informs‡ us that a female, taken in Massachusetts on July 13, had nine eggs, each three-

* Contributions, Vol. II, p. 491.

† Amer. Nat., Vol. XXV, p. 1091.

‡ Amer. Nat., Vol. II, p. 134.

fourths inch long and containing an embryo $2\frac{1}{2}$ inches in length. Another, taken July 31, contained but four eggs, and these are ready to be burst by the young. The eggs containing the coiled embryos were then an inch and a quarter long, while the extended young had a length of $5\frac{1}{2}$ inches. Dr. Goode has quoted* a note from Herman Strecker, of Reading, Pa., who states that some years previously he had found and caged a female of this species which soon produced thirty or more young ones. He supposed that the little snakes had been hidden in the mother's stomach. There is possibly some confusion here with *E. sirtalis*, judging merely from the number of the young. Prof. S. I. Smith, of the Sheffield Scientific School, is quoted† by Dr. Goode as having seen two young snakes, each 3 or 4 inches long, run down the mother's throat. The statement is no doubt incorrect, so far as regards the size of the young.

In a female (U. S. Nat. Mus., No. 17965) of the variety *faireyi*, taken probably in Mississippi, I find nine eggs, the hindermost three of which are in the left oviduct. The eggs are about three quarters of an inch long and a third of an inch in the short diameter. The development of the embryo had just begun. In a female (U. S. Nat. Mus., No. 17952) of *faireyi*, 28 inches long, taken at Veedersburg, Ind., are twelve ovarian eggs of the same size as those just mentioned. The hinder four are in the left ovary. At what time of the year the two specimens last described were killed, I do not know. In a specimen of *faireyi*, 40 inches long (U. S. Nat. Mus., No. 17958), captured at Vicksburg, Miss., about the 4th of July, there are twenty young snakes, each close to 9 inches in length. The hindermost nine of these are in the left oviduct. All were evidently ready to be expelled. They did not appear to be contained in any egg-covering, and the egg tooth was not found in any of the three which were examined. Not only is this date not so early as that given by Dr. Abbott for the finding of the eggs of this species in New Jersey, we must take into account the difference in the climate, and especially the difference in the size of the young snakes.

The species of the related genus *Tripidonotus* are also ovoviviparous. *T. sipedon*, our water-snake, is the commonest species of the genus in the eastern United States. It is extremely variable and reaches a large size. Prof. Putnam has a note regarding the breeding habits of this species.‡ He states that twenty two of the young belonging to one family were

*Proc. A. A. A. S., 1873, p. 18.

†Proc. A. A. A. S., 1873, p. —.

‡Amer. Nat., Vol. II, p. 134.

found. Each of them was 8 inches long. Dr. Heilprin mentions* a large specimen from which thirty-three young were taken. These were in different stages of development. Some of the larger ones had absorbed all the yolk, while to others a considerable mass of this was attached. In a specimen (U. S. Nat. Mus., No. 17962) from some point in northern Indiana I find sixteen eggs, eight in each oviduct. The young are $7\frac{1}{2}$ inches long, and each is provided with a well-developed egg-tooth. This is curved upward like a short horn, and tapers gradually to near the point, where it rounds off rapidly. The egg-membranes are thin. I have some reasons for believing that the larger specimens of this species will be found to produce a considerably larger number of young than the above observations indicate.

I have met with no statements regarding the breeding habits of either *Tripidonotus grahamii* or *T. leberis*, except that made by Miss Hopley,† to the effect that a specimen of the last-mentioned species in the Zoölogical Gardens produced in August five young and at the same time some eggs. What the state of development of these eggs was, and what became of them, we are not informed. I have a female specimen (No. 26) taken somewhere in Indiana, and in this I find eight eggs, of which three are in the left oviduct. There are no signs of beginning development. A gravid female (U. S. Nat. Mus., No. 17970), captured on July 15, and sent me by Mr. W. O. Wallace, of Wabash, Ind., is 24 inches long. There are eight eggs, two of which are in the left oviduct. The eggs are of different shapes, on account of pressure. A considerable amount of yolk is still present, an indication that the embryos are not yet completely developed. A measurement of one of these shows it to be $6\frac{1}{2}$ inches long. The longitudinal bands of the upper surface are sufficiently well displayed to enable one easily to determine the species, but the longitudinal brown ventral bands are not seen. I find no indications of the presence of the egg-tooth, although it is probably present.

Some years ago I killed a specimen of a female of *T. grahamii* in Bureau County, Ill. Of the specimen the skin and a few eggs (U. S. Nat. Mus., No. 17954) were preserved. The time of capture was about the middle of July or later. The mother snake was of such a rusty color that the species to which she belonged could not then be determined. One of the eggs measures an inch and a half in long diameter by three-quarters trans-

* Proc. Phil. Acad. Sci., 1887, p. 121.

† Snakes, etc., Miss C. C. Hopley, p. 437.

versely. A considerable mass of yolk is present, into one side of which an embryo snake is sunken. This embryo is 7 inches long; and, although thus immature, has its scales and its colors so perfect that there is no difficulty in assigning it to the proper species. The embryo is surrounded by a very thin egg-covering. No indications of the presence of the egg-tooth were seen until a series of sections through the snout were examined, when it appeared.

Tropidonotus kirtlandi is a rather common snake in central Indiana. One specimen (U. S. Nat. Mus., No. 17957) taken at Irvington contains three eggs in each ovary. Each egg is a little less than half an inch in length. Another specimen (U. S. Nat. Mus., No. 17953) from Winchester, Randolph county, has eight eggs in the ovaries. Each egg is seven-sixteenths of an inch in length. This species is in all probability ovoviviparous.

The species of *Storeria* are stated by Dr. Goode* to be oviparous; but Prof. Cope† regards them as ovoviviparous, and he is quite certainly correct in his conclusion. One female of *Storeria dekayi* sent me from Winchester, Ind., contains thirteen eggs, five of which are in the left ovary, the remainder in the right. The eggs have apparently not attained their full ovarian size. Another specimen (U. S. Nat. Mus., No. 17966) of this species, taken by Dr. D. S. Jordan, at Cumberland Gap, Tenn., about midsummer, is a foot long, and has in it eleven eggs, the hindmost three of which are in the left oviduct. Each egg is about three-eighths of an inch in length by one-quarter in short diameter. Another specimen (U. S. Nat. Mus., No. 17967), which was taken at Irvington, contains eight eggs in the oviducts, each including a very immature embryo an inch and a half in length. The eggs are about half an inch long. The membranes are extremely thin.

I find a few notes on the breeding habits of *Heterodon platirhinos*, the hog-nosed snake, viper, or spreading adder, as it is popularly known. Some of these contain statements which, to me, appear exaggerated. Dr. J. Schneck, of Mount Carmel, Ill., reports‡ that eighty-seven "young spotted spreading adders" were taken from the body of a wounded female. The author of the note did not see this done, but got his information from persons who did see it. I am strongly inclined to believe that the reptile was a *Tropidonotus sipedon*. Another writer§ in Pennsylvania gives an account of over one hundred young snakes issuing from a wound in the side of a female

*Proc. A. A. A. S., 1873, p. 184.

†Proc. Phila. Acad. Sci., 1874, p. 116.

‡Amer. Nat., Vol. XVI, p. 1008.

§Amer. Nat., Vol. III, p. 555.

spreading adder. These young were each from 6 to 8 inches in length, and all were active and blowing vigorously. Neither did the author of this note see the escape of the snakes, although he did see sixty-three of the young in alcohol. There may easily have been an error in the determination of the species to which these young snakes belonged. One who has examined the eggs of this species can not easily believe that so many young snakes could, with such readiness, escape from a wound in the mother's side. Moreover, these snakes deposit their eggs in the earth some time before the young are ready to lead an independent existence.

Dr. Bumpus (*op. cit.*, p. 364) states that a female *Heterodon* in the National Museum brought forth one hundred and eleven young; but Dr. Bumpus kindly informs me that he did not himself observe this.

Prof. F. W. Cragin reports* the finding, on September 10, of twenty-two eggs of this species. They were buried in the sand at East Hampton, Long Island. Two of the eggs, which he had in his possession, hatched four days afterwards. Troost appears to have dissected a black specimen, in which he found twenty-five eggs. Dr. C. C. Abbott says† that he has frequently in May found the eggs of the hog-nosed snake in considerable numbers, a few inches below the surface of the ground; and in early July he once found a family of 17 very small, and apparently just hatched, young. These resented all interference, snapped, hissed, and flattened their heads precisely as an older snake would do. The size of the young is not given, but in another place (*op. cit.* p. p. 295) he implies that they were less than 4 inches in length. I think that this species, like most other species, produce their young rather later in the season; but I see no reason for not believing that some individuals may bear their eggs over the winter and lay them in the spring.

A female (U. S. Nat. Mus., No. 17951), sent me from Veedersburg, Fountain county, Ind., contained fifteen eggs, the posterior four of which lay in the left oviduct. I could discover no signs of embryos. Each egg was covered by a thick, tough, yellowish coat, inside of which was a thinner and more delicate membrane.

Through the kindness of Dr. L. Stejneger, curator of the department of reptiles in the National Museum, I have been enabled to make some observations on the eggs and living young of this *Heterodon*. On the 31st day of last August, there were brought into the laboratory of the Department, from

*Amer. Nat., Vol. XIII, p. 710.

†Rambles, etc., p. 289.

some point in Maryland not far from Washington, a lot of twenty-seven eggs, which the finder said were the eggs of the copperhead. It was reported that the eggs were thrown up out of the ground by the plow, and that the mother snake was near by and had resented the disturbing of her treasures. She had been killed, but had not been sent along with the eggs. Since it was supposed that the copperhead produces living young, the occupants of the laboratory were anxious to learn if this opinion were erroneous. Accordingly one of the eggs was opened, and in it was found a young hog nosed snake, fully developed, and ready to assist himself on the stage of action. This *Heterodon* quite closely resembles the copperhead, and most people are not accustomed to make nice distinctions among snakes. This close resemblance may account for some of the statements of the large number of young produced by the copperheads.*

The eggs referred to were between an inch and a quarter and an inch and a half long, and about seven-eighths inch in short diameter. The egg covering was thick, tough, and flexible, resembling a piece of parchment. There is little if any deposit of lime in it. Of these eggs, some were found to have hatched during the night of September 6. Others, which were buried somewhat deeper in some clay, escaped from the eggs later; but all were out by the afternoon of the 8th. The length of such as were measured varied between 7 and 8 inches. From the moment of escape from the egg all were quite active, and manifested many of the characteristics of the adults. Some of the little fellows were quite saucy, and would make a pretense of striking at the approaching finger; but their efforts in that line were rather feeble. A faint hiss was sometimes uttered, but that may not have been voluntary. One would sometimes flatten its head and body and rear up with the anterior third of its length free from the ground. If one did not know well their inoffensive natures, one would be excused for fearing to handle them. An extremely singular habit possessed by the adults is that of feigning death. On being struck or teased they will roll over and over, as if in the intensest agony, and then throw themselves on the back and lie there as if dead. Out of some fifteen of the young experimented with, I succeeded in getting only two or three to go through with this performance, but these did it to perfection. On being lightly struck a few times, they would turn over on the back, writhe about a while, and then lie perfectly still. If turned right side up, they would again turn on the back. If left undisturbed for a little while they would turn over and

* Amer. Nat., Vol. XVII, p. 1235.

creep slyly away. The others of the young would not act in this way, however much they were teased. It would be interesting to know whether all the adults possess this odd habit, or only a portion of them.

The cuticle of the young *Heterodons* is shed very shortly after their escape from the egg-coverings. Within a few minutes after one had left its prison the skin was observed to be broken about the head. It had left the egg at half-past 1 and by 4 o'clock the skin was pushed back half the length of the body. The next morning the skin was wholly shed, revealing the brighter colors of the new skin. While getting rid of the cuticle the little reptile kept crawling over the clay and among the roots of grass.

The opportunity was embraced to observe the use which is made of the egg-tooth. The tooth itself is easily seen in the just-hatched snake. Its lateral borders are more nearly parallel than those of the tooth of *Bascanion* figured by Weinland. Seen from the side, the anterior or upper outline is concave, the posterior outline convex. Thus, the tooth projects forward and is turned slightly up. The anterior face is also concave from side to side, so that there is, on each side, a distinct cutting edge. The tip is cut off square. The tooth appears to have a ligamentous attachment, and may be lifted a little, but not much depressed. It seems quite evident that the tooth is first engaged in the egg-covering and then made to do its work by a forward push of the head. An examination of the covering, after the snake has left it, gives ample proof that it has been cut and not merely torn. The edges are as smooth as if they had been slashed with a razor. A long slit is sometimes made as if by a single effort. In other cases, several attempts appear to have been made before the covering has been open enough for the snake to get out. In one or two cases, a tooth has not been inserted deeply enough, and the only result was a scratch on the inside of the covering. The egg tooth having performed its office becomes loose and drops out. This occurs usually within twenty-four hours.

When the slit has been successfully made, the little snake may sometimes be seen pushing its head carefully out as if to survey the surroundings. Should there be any movement, the head will be quickly withdrawn.

I have been able to collect some facts concerning the pairing of the sexes of *Heterodon platirhinos*. Prof. U. O. Cox, of Mankato, Minn., informs me that he found two individuals uniting some time in May. A second male was entwined with the two other snakes. The latter were separated with difficulty. The male intromittent organs are described as being of an oval form, an inch long and over a half inch thick.

Two observers have seen black specimens, formerly called *H. niger*, pairing with the spotted individuals. Prof. W. S. Blatchley* found a black and a spotted one copulating on April 19. He speaks in a letter to me of the intermittent organs as being as large as a walnut, and covered with spines. Mr. E. R. Quick, of Brookville, Ind., an accurate observer of nature, writes me that he once found a black viper pairing with a spotted one. The time, he thinks, was late in June. The time of gestation of this species is not known. It may continue from spring until autumn. Possibly the late-pairing individuals may retain their eggs until the next spring. Nor do we know how long the eggs are laid before they are ready to hatch. These matters are known concerning very few of our snakes, and a wide field is offered for work and observation.

Of the *Colubers*, I have been able to make observations on *C. obsoletus* alone. It is likely that others have observed and written on the subject, but I have not met with their statements. Dr. G. B. Goode reckons† this species among those which are ovoviviparous, but I am inclined to question this. My son, W. P. Hay, captured two of these snakes, near Indianapolis, while they were in sexual union. This was on June 19. The male (U. S. Nat. Mus., No. 17948) was 5 feet 5 inches long, the female (U. S. Nat. Mus., No. 17949) 6 feet 3 inches. When they were separated, the intromittent organs of the male were everted some 3 inches. A dissection shows that the hollow portion of the organ extends behind the vent 3 inches, while the retractor muscles form a cord which extends back nearly to the tip of the tail. At the base of the eversible portion, near the vent, the inner surface, which when the organ is everted becomes the outer surface, is furnished with numerous plications. Near the middle of the organ are found many hooked papillæ, some of them large and horny. The remainder of the organ has the surface raised up into numerous anastomosing folds, so that under the microscope it reminds one of the reticulum of the ox's stomach. On opening the female I find in her sixteen eggs. Of these eggs, four lie about the middle of the animal's body, while the other twelve occupy a much more anterior position; the one farthest forward being within 8 inches of the tip of the snake's snout, the hindermost one only 9 inches farther back. Several of these eggs are lying apparently loose in the body cavity. It might be supposed that they had just left the ovary and were about to enter the oviduct; but they are surrounded each

*Jour. Cincinnati Soc. Nat. Hist., 1891, p. 31.

†Proc. A. A. A. S. 1873, p. 185.

with a covering nearly as thick and tough as that of the egg of the *Heterodon*. Could these eggs have been in the oviducts and then squeezed out into the body cavity during the time of being entwined with the male? The thickness of the egg covering makes it appear to me highly probable that the eggs are destined to be laid before the young will be mature enough for independent existence.* †

Some years ago, in midsummer, I found a number of the eggs of the house snake which had been deposited in a pile of stable manure. This was in Bureau county, Ill. No record was kept of the number of the eggs, but a few of them (U. S. Nat. Mus., No. 17955) were preserved in alcohol. When found, the eggs were glued together into one mass. Each egg is 2 inches long and nearly an inch and a quarter in the short diameter. On the outside is found a thick, leathery, yellow covering, beneath which is a much thinner coat. From one of these eggs I have taken a young snake which measures $10\frac{3}{4}$ inches in length. Attached to this embryo is a considerable mass of yolk, a condition which indicates that the embryo is not ready for hatching. Nevertheless, all the generic and specific characters are well shown. There is a well-developed egg-tooth. The intromittent organs are everted in the specimen examined. Each consists of a rather slender and twisted basal stalk, at the end of which is the swollen glans. This is acorn-shaped at the base, but terminates, at the distal end, in two blunt lobes. The base of the glans is densely spinose, the remainder reticulately papillose. The seminal groove winds around the basal stalk and terminates at the tip of one of the terminal lobes, the larger one.

Concerning the breeding habits of the black-racer, *Bascanion constrictor*, I find little in print. It is well known that the young differ markedly from the adults, being decidedly spotted. Dr. Weinland, as already stated,

* Since the above has gone to press, I have had the opportunity, April 29, of dissecting a recently captured female, the length of which was 4 feet 4 inches. The ovaries lie in the region situated about two thirds the distance from the head to the vent. Each oviduct ends close to the corresponding ovary. It seems evident, therefore, that at least some of the eggs of the specimen described above are really lying loose in the body cavity. In the specimen dissected, the ovarian eggs are very immature, none of them exceeding about a quarter of an inch in length. It may be of some interest to add that this female had the anterior three-fourths of the body ornamented with blotches of a decided red color, the red occupying both the surfaces of the scales and the skin between them. The blotches were separated by scales which were partly yellow. Soon after death a great part of the red disappeared. The stomach contained eight wild mice, six of them young.

† I am able to state that *Coluber obsoletus* is oviparous. Mr. Thomas Marron, of the National Museum, early in April, 1889, collected a number of snake eggs in a hollow stump near the Potomac river. They were opened and found to contain fully developed young of this species, (U. S. Nat. Mus., No. 15331).—Leonhard Stejneger.

described the egg-tooth. In one female, taken near Indianapolis, I find nineteen eggs, seven of which lie in the left ovary. These eggs are quite immature.

Some alcoholic eggs (U. S. Nat. Mus., No. 17956) of this species from an unknown locality furnish some points. They are of the usual elongated oval form, an inch and a half long and close to an inch in short diameter. The outer covering is thick and tough, and it is furnished with numerous hard points, as if of deposits of lime salts. Within the egg is a young racer $10\frac{1}{2}$ inches long and evidently nearly ready to come forth. The intromittent organs of this specimen are somewhat flattened, broad at the extremity, and with prominent terminal angles. The organ begins to expand from its base. It is furnished plentifully with spines. When the sexes unite, when the eggs are laid, how concealed, and when they hatch, are some of the things which we need to learn.

I have examined a specimen (U. S. Nat. Mus., No. 17969) of *Haldea striatula* from some point in Arkansas. It is $9\frac{1}{2}$ inches long and contains five eggs, each with a young *Haldea* in it. Only the hindmost egg is in the left oviduct. This is a little over an inch long, but the others are only a little more than three-quarters. The short diameter of the egg is about a quarter of an inch. The embryos are far from mature, being only $2\frac{3}{4}$ inches long when extended. They have a considerable mass of yolk still attached to them. The egg-coverings are very thin. This circumstance causes me to conclude that the young are brought forth alive. A series of sections through the snout of an embryo reveals the presence of the usual egg-tooth.

SOME OBSERVATIONS ON THE TURTLES OF THE GENUS *MALACLEMYS*. By O. P. HAY.

Of the turtles belonging to the genus *Malaclemys* there are now recognized five species, two new ones having been described within recent years by Dr. G. Baur. The genus is a very distinct one, and is distinguished from *Chrysemys* especially by the extremely broad and flat crushing surfaces of both upper and lower jaws. As a result of the provision made for the support of these wide, horny, masticatory plates, the internal nares are thrown far back, so as to lie behind the level of the eyes. In the Catalogue

of the Chelonians in the British Museum, 1889, Dr. G. A. Boulenger says that the "plastron is extensively united to the carapace by suture, with feeble axillary and inguinal peduncles, the latter ankylosed to the fifth costal plate." Sometime ago I macerated a large specimen, *M. geographica*, until the whole plastron fell away from the carapace, thus showing that there was no ankylosis of the parts.

The Map tortoise, *M. geographica*, was described by the naturalist Le Sueur, in the Journal of the Philadelphia Academy for 1817. In the Mémoires du Muséum de Paris for 1827, Le Sueur presented the description of another species of this genus from specimens which he had taken in the Wabash river, at New Harmony, Ind. Neither figure nor systematic name accompanied the description, although he appears to have had a name in manuscript, *pseudogeographica*. It is evident that Le Sueur had in mind the terrapin, which has for the most part gone by that name since then, although the description is in some respects erroneous. The first mention that I find of this manuscript name of Le Sueur is found in connection with the *Emys lesueurii*, described by Dr. J. E. Gray in his Synopsis Reptilium, 1831. It is also given by Duméril and Bibron in Erpétologie Générale, vol. II, p. 256, as a synonym of *Emys geographica*, with the remark, "jeune age." In his work, Herpetology of North America, published in 1842, Dr. Holbrook recognized the fact that this terrapin is distinct from the earlier described *geographica*, and gave to it the name that Le Sueur had bestowed on it in his manuscripts. He also accompanied the description with a colored plate. It is from this date, 1842, that we must reckon in determining the tenability of the name *pseudogeographica*.

In 1831 Dr. J. E. Gray, in his Synopsis Reptilium, p. 31, published a description of a species which he called *Emys lesueurii*. This supposed new species was founded on either a specimen of *geographica* or on one of what Holbrook afterwards called *pseudogeographica*. Dr. Gray himself, in all his subsequent publications, wrote down the name *lesueurii* as a synonym of *geographica*, although previously to the publication of his Catalogue of the Shield Reptiles he did not recognize Le Sueur's *pseudogeographica* as being distinct from the earlier described *geographica*.

In 1857 Louis Agassiz, in his Natural History of the United States, arranged both the species referred to under the genus *Graptemys*. Of his *Graptemys lesueurii* he says: "This species is commonly called *Emys pseudogeographica*, but the specific name *Le Sueurii* is older. It is evident from his reference that Gray at first applied the name of *Emys Le Sueurii* to this

species, and not to *Gr. geographica*; now Gray calls it also *Emys pseudogeographica*" Since that time Prof. E. D. Cope, in his Check List of 1875, employed the name used by Holbrook, but Mr. F. W. True, in Dr. Yar-row's Check List of 1882, adopted Agassiz's suggestion and called the species *Malacoclemys lesueurii*.

Since now the name by which we are to know the species called by Le Sueur and Holbrook *pseudogeographica* depends on what Gray had before him when he described his *Emys lesueurii* it becomes necessary, if possible, to determine that matter. More certainly depends on that than on Gray's references to any previous writings.

Among other differences existing between the two species of *Malaclemys* referred to here, is one which enables us in all cases to distinguish them. This is found in the form of the yellow spot which lies on the side of the head just behind the eye. In *M. geographica* this spot is broad, rather triangular, and elongated in the direction of the head. In the other species the spot is a transverse streak, running behind the eye and sometimes curving forward below it. Now, in his description of *Emys lesueurii*, Gray has this language: "Temporibus macula triangulari notatis." At the end of his description he further says: "*Emys geographica* of Le Sueur agrees with the museum specimen, except in that the first vertebral plate is not urn shaped, and Le Sueur does not notice the triangular temporal spot." In that remark we have evidence that Gray had before him but a single specimen and that that specimen had the "ear-mark" of *geographica*. We further learn why he described it as different from Le Sueur's species. That Gray was at this time aware of the existence of Le Sueur's manuscript name appears from the following words at the end of the description:

" β , Scutello vertebrali primo urceolato." *Emys geographica*, Lesueur, Jour. Acad. N. S. Phil. t. *Emys pseudogeographica*, Lesueur Mss. (Mus. Paris).

This is probably the reference that Agassiz alludes to, and it is hard to see why Gray introduces it here; but it no more proves that he had Le Sueur's *pseudogeographica* in mind than the other species. Indeed, he regarded them as both the same thing. Furthermore, in his Catalogue of the Shield Reptiles, he refers this β to *pseudogeographica*, while his *lesueurii* is referred to *geographica*. It is evident that he regarded what he placed under β as different from the species he was describing. I make the suggestion that the quotation marks were put in front of the β through an error of writing or printing. As to the characters assigned to *lesueurii*, I submit that they apply much better to *M. geographica* than to *pseudogeographica*.

The subsequent history of these two species, so far as Dr. Gray is concerned, is as follows: In the Catalogue of Tortoises, published in 1844, he regards both *pseudogeographica* and *lesueurii* as synonyms of *geographica*. He does not appear at this time to have seen Dr. Holbrook's work of 1842. In his description of the *geographica* of the Catalogue of Tortoises, Dr. Gray says of the head-spot only that it is "a yellow streak on the temple." In making this description he had before him two specimens, which according to his plan, he designates as *a* and *b*. Was either of these the one on which he had in 1831 based the species *lesueurii*? This is of some importance and will presently be considered.

By the time of the publication of the Catalogue of Shield Reptiles, in 1855, Dr. Gray had undergone another change of mind. He now recognized the existence of two entirely distinct species, and these he designates as *Emys geographica* and *E. pseudogeographica*. Of the latter species there were then in the British Museum seven specimens, five of which had certainly been received since 1844. The other two are distinctly stated to be the ones which had been recorded as *a* and *b* under *Emys geographica* in the work of 1844. Of *Emys geographica*, on the other hand, there was in 1855 only a single specimen in the Museum and that is expressly said to be the one which furnished the description of *E. lesueurii* in 1831. Even then Gray seemed to be a little doubtful about its being the same as Le Sueur's *geographica*, but his description of it removes all doubt. He contrasts it sharply with the specimens of *pseudogeographica*.

All these facts indicate that in 1844, when Gray wrote the Catalogue of Tortoises, the type of *E. lesueurii* was not in his hands. It had probably been misplaced and for the time being lost. The descriptions of that work had been drawn from two specimens of *pseudogeographica*. When the Catalogue of Shield Reptiles was written, the specimen had been recovered, and Gray was enabled to compare it with specimens of the other species and with Holbrook's descriptions and figures. It is spoken of as "animal dry from spirits," "the Museum specimen is in a bad state." Something concerning its history may be inferred from these remarks.

Dr. Boulenger, in his Catalogue of Chelonians, 1889, accepts the specific name *lesueurii*, instead of *pseudogeographica*. No mention is made of the specimen which served Dr. Gray as the type of *lesueurii*.

With the evidence before us, we must, it seems to me, accept the name *pseudogeographica* for the species under consideration. To reject it will be to ignore Gray's statements, repeatedly made, that his *lesueurii* is a syno-

nym of *geographica*, as well as the plain language of his descriptions. It may be a very objectionable name, but the laws of priority must be rigidly observed.

The masticatory surfaces of *M. geographica* are much broader than those of *M. pseudogeographica*, and we might infer therefrom that the food of the two species is not the same. In Volume XXII of the Bulletins of the Essex Institute, Prof. Harry Garman has made the observation that the broad surfaces of *M. geographica* are employed in crushing the shells of mollusks, the remains of which he found in their stomachs. In the stomachs of *M. pseudogeographica*, on the other hand, he found the remains of a species of sedge, as well some animal matter. During the month of May, 1891, at a meeting of the Indiana Academy of Sciences at Lake Maxinkuckee, in northern Indiana, three or four of us, within a few hours captured about thirty specimens of *M. geographica*. These specimens were almost invariably taken in the water near the shores of the lake where the bottom was covered with the shells, living and dead, of *Viripara contectoides*. Seven of the terrapins were taken home and kept some days in a washtub partially filled with water. When they were taken out, there were found on the bottom of the tub large numbers of the opercula of that water snail. In the alimentary canal of one terrapin were found these opercula, as well as the remains of crayfishes, and what appeared to be the cases of some species of caddis-worm. The masticatory surfaces of the older specimens were found to be much worn. The crushing surfaces of Dr. Baur's recently described *M. oculifera* are rather narrow, while the cutting edges of the jaw are very sharp. The indications are that the food does not consist of mollusks, but rather of some soft vegetable and animal substances.

Most, if not all, the species of this genus are extremely variable in the size of the head. In the paper referred to above, Prof. Garman attempts to give us the characters that distinguish *geographica* from *pseudogeographica*, and among such differential characters is the size of the head relative to length of the carapace. *Geographica* is stated to have a large head; *pseudogeographica* a much smaller head. He also presents measurements that appear to prove his position. Dr. Holbrook long ago described a specimen of *geographica* under the name of *Emys megacephala*, the name being suggested by the massive head. Some years ago Dr. Gray suggested that the large head might be a sexual character, but he did not state which have the big heads, the males or females. Through the kindness of Dr. Stejneger, I have been permitted to examine all the specimens of both species that

are in the National Museum, and I have also examined a number of specimens of both the species in my own collection. I find that the size of the head is not a specific, but a sexual, character, and that it is the females which have the large heads. The heads of the males are much smaller and also more pointed. I believe that the same statements are true regarding the salt-water terrapin, *Malaclemys terrapin*, although I have not been able to examine a sufficient number of specimens to be certain about it. With regard to the other two species referred to I am quite certain that no appreciable differences will be found between them, when we compare specimens of the same size and sex.

Another interesting matter pertaining to most, if not all, the species of this genus is the size of the male as compared with that of the female. Le Conte is the only author who has, so far as I am aware, made the observation that the male of the salt-water terrapin is small. Of the seven specimens of *M. geographica* taken by myself at Lake Maxinkuckee, three had the carapace $3\frac{1}{2}$ inches long, while the other four had a length of carapace ranging from $6\frac{1}{2}$ to 9 inches. Dissections proved that all the small specimens were males and the large ones females. The same statements are true of such specimens of *M. pseudogeographica* as I have examined. All the specimens of *M. oculifera* Baur in the National Museum are, judging from the form of the shell, females; and they are all large specimens. Both Agassiz and Baur have observed that the males of *Trionyx spiniferus* are smaller than the females. On the other hand, the largest specimen of *Chelydra serpentina* that I have ever seen was a male, and I believe that the males of the various species of the genus *Chrysemys*, as defined by Boulenger, exceed the females in size.

It is quite characteristic of the species of the genus *Malaclemys* to have a prominent keel along the middle of the carapace, and this is often nodose. In *M. pseudogeographica* the keel is nodose all through life. However, all the species, so far as we know, have these elevations along the keel when young. In some of the young of the salt water terrapin I found that the nodosities were especially large and globular. They resembled greatly a row of medium-sized peas, four or five in number, lying along the back. The species *M. geographica*, having such a nodose keel while young, but losing it as age advances, must be regarded as attaining a higher stage of development than *pseudogeographica*, which retains this embryonic character throughout life. The young of *M. oculifera* will undoubtedly be found to have a distinct and nodose keel.

Agassiz (*loc. cit.* p. 260) discusses the various ways in which the different kinds of turtles get rid of the older layers of the epidermis. He mentions certain species of fresh-water turtles, among them *M. pseudogeographica* in which he observed in the spring the uppermost layer of the dermal plates to be cast off at once as one continuous, thin, mica-like scale all over the plate. In a number of very young specimens of *M. geographica* taken at Lake Maxinkuckee, the outer layer of the epidermis was lifted up from the underlying layers by a quantity of fluid. This was preparatory, no doubt, to the casting off of the epidermal layer.

THE GRYLLIDÆ OF INDIANA. By W. S. BLATCHLEY, A. M., Terre Haute, Ind.

The *Gryllidæ* or crickets are, in the main, distinguished from other *Orthopterous* insects, by having the wing covers flat above and bent abruptly downward at the sides; the antennæ long, slender, and many jointed; the tarsi, or feet, three jointed, without pads between the claws; the ear situated on the tibia of the fore leg; and the abdomen bearing a pair of jointed cerci or stylets at the end.

The ovipositor of the female, when present, is long, usually spear-shaped, and consists, apparently, of two pieces. Each of these halves, however, when closely examined, is seen to be made up of two pieces so united as to form a groove on the inner side, so that when the two halves are fitted together, a tube is produced, down which the eggs pass to the repository in the earth or twig, fitted to receive them.

The inner wings are, for the most part, short, weak, and comparatively useless as flying organs, though, sometimes, they are nearly twice as long as the outer pair. Like their nearest relatives, the grasshoppers and katydids, crickets travel mostly by leaps and, in the course of time, their hind femora have thus become greatly enlarged.

The chirps or love calls of the different species of crickets make up the greater part of that ceaseless thrill which fills the air, usually at night, from mid-August until after frost. These sounds are made only by the males, and are not vocal, as most persons suppose; but are produced by rubbing the veins in the middle of one wing cover upon those of the other. The peculiar structure of this stridulating organ of the male, as well as the high

specialization of the ovipositor in the female, have led entomologists to classify the *Gryllidae* as the highest family of the ORTHOPTERA.

Representatives of nine genera and sixteen species of these interesting insects from Indiana are in the writer's collection, several of which are exceedingly abundant throughout the state.

A belief that a brief and popular description of the leading characters of each of these species, together with some account of their habits, as noted during a number of years of observation, would prove acceptable to persons interested in the study of such creatures, has prompted the preparation of this paper. In order to render it as complete as possible for reference purposes, and thereby aid the younger entomologists of the state, a synonymy of each species has been compiled from such works as were accessible and appended to the name of that species. The following is a full list of the authors and publications to which reference is made in the synonymy given:

Comstock, J. H.—An Introduction to Entomology, I, 1888.

Fernald, C. H.—The Orthoptera of New England, 1888.

Fitch, Dr. Asa.—Third Report on the Noxious Insects of New York, 1856.

Glover, Townsend.—Report of U. S. Entomologist in the U. S. Agricultural Report for 1874.

Harris, Dr. T. W.—Treatise on Some Insects Injurious to Vegetation. Third edition, 1862.

McNeill, Jerome.—A List of the Orthoptera of Illinois, Psyche, VI, 1891.

Packard, A. S., Jun.—Guide to the Study of Insects. Eighth edition, 1883. Fifth report U. S. Entomological Commission, 1890.

Rathvon, S. S.—In the U. S. Agricultural Report, 1862.

Riley, Dr. C. V.—Orthoptera in the Standard Natural History, II, 1884.

Say, Thomas.—The Entomology of North America. LeConte edition, 1859.

Scudder, Samuel H.—Materials for a Monograph of the N. A. Orthoptera, in the Boston Journal of Natural History, VII, 1862. Catalogue of the Orthoptera of N. A., 1867. The Distribution of Insects in New Hampshire, in the first volume of Final Report upon the Geology of New Hampshire 1874.

Thomas, Cyrus H.—Insects Injurious to Vegetation in Illinois, in the Transactions of the Illinois State Agricultural Society, V, 1865.

Uhler, Philip R.—Orthopterological Contributions in the Proceedings of the Entomological Society of Philadelphia, II, 1864.

Walsh, B. D.—In the Practical Entomologist, vols. I and II, 1867.

Various Authors.—Insect Life, vol. II, 1889. Canadian Entomologist, XXIV, 1892.

The following artificial key will enable the student to more readily distinguish the different genera of *Gryllidæ* found in Indiana.

- a. Fore tibiæ broad, fitted for digging.
 - b. Length of body more than one-half of an inch. . . II. *GRYLLOTALPA*.
 - bb. Length of body less than one-half of an inch. . . I. *TRIDACTYLUS*.
- aa. Fore tibiæ slender.
 - c. Hind femora slender. . . IX. *ECANTHUS*.
 - cc. Hind femora robust.
 - d. Last segment of the maxillary palpus very nearly of the same length as the one preceding.
 - .e. Head as broad as or broader than the posterior margin of the pronotum; color black or dark brown. . . III. *GRYLLUS*.
 - ee. Head narrower than the posterior margin of the pronotum; color light brown or dark yellow. . . VII. *OROCHARIS*.
 - dd. Last segment of the maxillary palpus, very nearly, or fully, double the length of the one preceding.
 - f. Last segment of the maxillary palpus broadly flattened. . . VI. *PHYLLOSCIRTUS*.
 - ff. Last segment of the maxillary palpus club-shaped but not flattened.
 - g. Ovipositor much compressed, curved strongly upwards. . . V. *ANAXIPHUS*.
 - gg. Ovipositor of the normal form (cylindrical) curved but slightly upwards.
 - h. Head as broad as, or broader, than the posterior margin of pronotum. . . IV. *NEMOBIUS*.
 - hh. Head narrower than the posterior margin of pronotum. . . VIII. *APITHES*.

FAMILY. *GRYLLIDÆ*.—The Crickets.

I. *TRIDACTYLUS*, Olivier (1789.)

To this genus belong some of the smallest of the *Gryllidæ*, no one of the three species found in the United States being more than 10 mm., or two-

fifths of an inch, in length. The generic name, *Tridactylus*, is based upon the peculiar structure of the anterior tibiae which are much dilated and armed at the end with three strong and slightly curved spurs. The outer wings, or tegmina, are horny and opaque and do not reach the end of the abdomen, while the inner wings are longer and folded lengthwise like a fan. The hind femora are enlarged and the insects are active leapers. But one species has as yet been taken in Indiana, though another one doubtless occurs in the northern half of the state.

I. *TRIDACTYLUS APICALIS*, Say.

Tridactylus apicalis, Say, Ent. N. A., (Ed. Le Conte), II, 239.

Scudder, Bost. Jour. Nat. Hist., VII, 1862, 425.

Packard, Guide Stud. Ins., 1883, 563.

Riley, Stand. Nat. Hist., II, 1884, 180.

McNeill, Psyche, VI, 1891, 3.

This is the largest of the three species occurring in the U. S., its length being 8 or 9 mm.* The body is deep black, the head and thorax with some white markings, and the tegmina with their outer edge and a spot behind the middle white. The hind femora are whitish, with three faint, dark cross bars. The wings of the male extend three mm. beyond the tip of the abdomen.

Apicalis, is stated by most of the authorities cited above, to be a southern species, but has been taken as far north as Quincy, Illinois. In Indiana it has, so far as known, been noted only in Vigo county, where a few specimens were discovered along the banks of a small stream during the latter part of October, 1891. They evidently dwell in little pits or burrows in the soft sand or mud, as numerous openings of such places were found, from one or two of which specimens emerged and leaped into the water on which they floated for an instant and then sprang back onto the bank. The most of the inhabitants of the pits had, no doubt, been killed by the frost before the species was discovered, and another season will have to arrive before anything distinctive of their habits can be learned.

II. *GRYLLOTALPA*, Latreille (1807). The Mole Crickets.

Among the Gryllids found in Indiana the burrowing or mole crickets rank first in size and singularity of structure. When full grown they measure from an inch and a fourth to an inch and a half in length; are light brown in color and have the body covered with very short hairs, giving to it

* The measurements in this paper are usually given in millimetres. An inch is equal to very nearly 25 mm.

a soft, velvety appearance. The females have no visible ovipositor, and, externally, may be separated from the males only by the difference in the veining of the uppermost of the wing covers. By their habit of burrowing beneath the soil in search of such food as the tender roots of plants, earth worms and the larvæ of various insects, the anterior tibiæ of these crickets have, in the course of ages, become so modified in structure as to closely resemble the front feet of the common mole, whence the generic name, *Gryllotalpa*, from "*gryllus*," a cricket, and "*talpa*," a mole. Moreover, the compound eyes have become very much aborted, being not more than one-eighth the size of those of the common field cricket, *Gryllus abbreviatus*, Serv., and, as the insect crawls rather than leaps, the hind femora are but little enlarged. Two species occur in Indiana.

2. *GRYLLOTALPA BOREALIS*, Burmeister. The Northern Mole Cricket.

Gryllotalpa borealis, Scudder, Bost. Journ. Nat. Hist., VII, 1862, 426.

Id., Dist. Ins. in N. H., 1874, 363, pl. A, fig. 7.

Id., Amer. Nat., X, 1876, 97, (The chirp of set to music).

Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 441.

Glover, U. S. Ag. Rep. 1874, 143, fig. 17.

Packard, Guide to Stu. Ins., 1883, 563.

Fernald, Orth. N. Eng., 1888, 14, fig. 6.

Comstock, Int. to Entom., I, 1888, 120, fig. 121.

NcNeill, Psyche, VI, 1891, 3.

Fletcher, Can. Entom. XXIV, 1892, 23, fig. 1.

Doran, Can. Entom., XXIV, 270, (Life history of).

Gryllotalpa brevipennis, Harris, Ins. Inj. to Veg., 1862, 149, fig. 68.

Rathvon, U. S. Ag. Rep., 1862, 378, fig. 12.

The northern mole cricket may be known by the shortness of its outer wings which are less than half the length of the abdomen, while the inner wings extend only about one-sixth of an inch beyond them.

In the moist mud and sand along the margins of the smaller streams and ponds their runs or burrows, exactly like those of a mole though much smaller, can in late summer and early autumn be seen by those interested enough to search for them. These runs usually end beneath a stone or small stick, but the insects themselves are very seldom seen, as they are nocturnal, forming their burrows by night, and scarcely ever emerging from beneath the ground.

The note of the male is a sharp disyllabic chirp, continuously repeated

and loud enough to be heard several rods away. It is usually attributed, by those who have given little attention to insect sounds, to the field cricket or to some of the smaller frogs. They are very difficult to locate by this note, and the writer has on several occasions approached cautiously, on hands and knees, a certain spot and has remained silent for minutes while the chirping went on apparently beneath his very eyes; yet, when the supposed exact position of the chirper was determined and a quick movement was made to unearth him he could not be found. Indeed it is only by chance, as by the sudden turning over of a log in a soft, mucky place, that a person can happen upon one of them unawares. Even then quick movement is necessary to capture him before he scrambles into the open mouth of one of the deep burrows which he has ever in readiness.

The eggs of the northern mole cricket are laid in underground chambers in masses of from forty to sixty, and the young are about three years in reaching maturity. On this account, where they exist in numbers, they are very destructive, feeding, as they do during that time, mainly upon the tender roots of various plants. It is therefore fortunate that with us the species is not more common than it is. It has been noted in Wabash, Tippecanoe, Vigo, Putnam and Monroe counties, and is probably found throughout the state, though nowhere abundant.

Average measurements, of twelve specimens: Length of body, 33, mm.; of wing covers, 10 mm.; of wings, 14 mm.

3. *GRYLLOTALPA COLUMBIANA*, Scudder.—The Long-winged Mole Cricket.

Gryllotalpa longipennis, Scudder, Bost. Jour., Nat. Hist. VII, 1862, 426.

Packard, Guide to Stud. Ins., 1883, 563.

Gryllotalpa columbiana, Fernald, Orth. N. Eng., 1888, 14.

McNeill, Psyche, VI, 1891, 3.

This cricket was first described by Mr. Scudder, *loc. cit.*, under the specific name of *longipennis* which he afterwards changed to *columbia*, the former name being pre-occupied by an East India species of this genus.

It appears to be very rare in Indiana, a single male specimen captured in Clinton county, being the only one known from the state. Packard, *loc. cit.*, says that it is a southern species, but it has since been recorded from Illinois, Iowa and Kansas.

In size and general appearance it closely resembles *G. borealis*, but it may be known from that species by the much greater length of the wings which extend, in the specimen mentioned, 10 mm. beyond the tip of the

abdomen; and by the longer and more slender teeth of the anterior tibiae. Nothing of its habits is known to the writer, but they are probably nearly or quite the same as those of the preceding species.

Length of body, 28 mm.; of wing covers, 12 mm.; of wings, 24 mm.

III. GRYLLUS, Linnæus (1758). The Field and House Crickets.

To this genus belong those dark colored, thick-bodied crickets, mature specimens of which are so abundant from late summer till after heavy frosts, beneath logs, boards, stones, and, especially, beneath rails in the corners of the old-fashioned and rapidly disappearing Virginia rail fences. Three species of *Gryllus* are known to occur in the state.

4. GRYLLUS ABBREVIATUS, Serville. The Short-winged Field Cricket.

Acheta abbreviata, Harris, Ins. Inj. Veg., 1862, 152, fig. 69.

Rathvon, U. S. Agr. Rep., 1862, 380, fig. 15.

Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 442.

Walsh, Practical Entomologist, I, 1866, 126.

Gryllus abbreviatus Scudder, Bost. Jour. Nat. Hist., VII, 1862, 427.

Packard, Guide to Stud. Ins., 1883, 564.

Fernald, Orth. N. Eng., 1888, 15.

Comstock, Intr. to Entom., I, 1888, 121, fig. 108 a.

McNeill, Psyche, VI, 1891, 5.

This is the most common and familiar species of the genus occurring in the state. The males have the wing covers usually reaching to the end of the abdomen, but those of the females are much shortened and reach but little beyond its middle. The wings are sometimes wanting but are usually present and much shorter than the wing covers. The ovipositor is almost as long as the body, and the hind femora are exceedingly thick and have a brick red spot at the base on the under side.

Each of the authorities cited above, who says anything of the life history of this cricket states that the eggs are laid in the ground in autumn and hatch the following summer, but the writer has, many times, taken the half grown young from beneath logs in late autumn and in mid winter. On such occasions they are usually found in a dormant condition, each one at the bottom of a cone shaped cavity which it has formed for itself, and which is very similar to the pits made in loose sand by the larva of the ant lion, *Myrmecleon obsoletus*, Say. Many specimens which had evidently moulted twice were taken thus on February 8th, 1890, and during the three months just passed, (Oct., Nov., and Dec., 1891), the young have

been noted in numbers each time the woods were visited, though no mature specimens have been seen since October 20th. The young seen in winter are not numerous enough to develop into the mature specimens of the succeeding autumn, and, in my opinion,* those eggs which are laid in early fall hatch and the insects hibernate in the burrows mentioned above; while the greater number of eggs, deposited later, do not hatch till the following season.

The short-winged field cricket is nocturnal, omnivorous, and a cannibal. Avoiding the light of day, he ventures forth, as soon as darkness has fallen, in search of food, and all appears to be fish which comes to his net. Of fruit, vegetables, grass and carrion, he seems equally fond and does not hesitate to prey upon a weaker brother when opportunity offers. I have often surprised them feasting on the bodies of their companions, and of about forty imprisoned together in a box, at the end of a week but six were living. The heads, wings, and legs of their dead companions were all that remained to show that the weaker had succumbed to the stronger—that the fittest, and in this case the fattest, had survived in the deadly struggle for existence.

Average measurements: Females—Length of body, 24 mm.; of posterior femora, 15 mm.; of wing covers, 11 mm.; of ovipositor, 22 mm. Male—Length of body 21 mm.; of posterior femora, 14 mm.; of wing covers, 11 mm.

5. *GRYLLUS LUCTUOSUS*, Serville. The Long-winged Cricket. The House Cricket.

Gryllus luctuosus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 427.

Id., Distribt. of Ins. in N. Hamp., 1874, 363.

Thomas, Geol. Surv. Terr., 1871, 433, pl. I, figs. 10, 11.

Packard, Guide to Stud. Ins., 1883, 564.

Fernald, Orth. N. E., 1888, 15.

Comstock, Intro. to Ent., 1888, 121.

McNeill, Psyche, VI, 1891, 4.

This is a species of wide range, occurring throughout the entire United States, but it appears to be somewhat rare in Indiana, having been taken only in Vigo and Parke counties. From the preceding species, which it

*Since verified by a letter received from Dr. C. V. Riley, in which he states that "the periods are very irregular and the egg laying undoubtedly continues for a considerable space of time."

almost equals in size, it is readily distinguished by the shorter ovipositor of the female, and by the greater length of the inner wings which, in both sexes, extend about 7 mm. beyond the tip of the abdomen.

Mature specimens have been taken as early as June 1, so that it, also, must winter in the larval state. It seems to be more fond of the society of man than any other species, and is the one which was usually heard chirping about the hearths of the large, old-fashioned fire-places. It is often found about houses and barns in towns and cities, and a number of specimens have been secured by the writer from beneath electric lights.

All the measurements of both this and *G. abbreviatus*, exceed those given by Mr. Scudder, in his paper in the Boston Journal, *loc. cit.*, yet, otherwise, Indiana specimens fully agree with the descriptions.

Measurements: Male and female—Length of body, 21 mm.; of posterior femora, 13 mm.; of ovipositor of female, 14 mm.

6. *GRYLLUS PENNSYLVANICUS*, Burmeister.

Gryllus pennsylvanicus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 429.

Thomas, Trans. Ill. St. Agr. Soc., V, 1865, 443.

McNeill, Psyche, VI, 1891, 4.

Several females of a short, broad-bodied cricket have been taken in Vigo county, which are evidently distinct from either of the above members of this genus, and are referred with some doubt to this species. The wing covers reach to the end of the abdomen while the posterior femora and ovipositor are much shorter than those of the two preceding species. The body in the longest specimen measured but 15 mm., and the wings of all were very much abbreviated or absent. They were taken in September from beneath logs.

Average measurements: Length of body, 14 mm.; of wing covers, 10 mm.; of posterior femora, 8 mm.; of ovipositor 7 mm.

IV. *NEMOBIUS*, Serville (1839). The Striped Ground Crickets.

Of all the Gryllidæ which occur in the Northern states, the little brown ground crickets are the most numerous and the most social. Unlike their larger cousins, the field crickets, they do not wait for darkness before seeking their food, but wherever the grass has been cropped short, whether on shaded hillside, or in the full glare of the noonday sun along the beaten roadway, mature specimens may be seen by hundreds during the days of early autumn. They are all of small size, being never more than half an inch in length. The color is a dark brown, and the bodies and legs are

sparsely clothed with brown hairs. The head is broad, the ovipositor of normal shape, and the last segment of the maxillary palpus is twice the length of the one preceding it, whereas in the species of *Gryllus* the two segments are of equal length. Three species of *Nemobius* occur in Indiana.

7. *NEMOBIUS VITTATUS*, Harris. The Wingless Striped Cricket.

Acheta vittata, Harris, Ins. Inj. to Veg., 1862, 152, fig. 70.

Rathvon, U. S. Agr. Rep., 1862, 380, fig. 16.

Nemobius vittatus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 430.

Id. Dist. of Ins. N. H., 1874, 364, (Chirp set to music).

Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 443.

Scudder, Am. Naturalist, II, 1868, 115, (Song of).

Packard, Guide Stud. Ins., 1883, 564.

Fernald, Orth. N. Eng., 1888, 16.

Comstock, Int. to Ent., I, 1888, 121.

In both sexes of this, our most abundant species, the inner wings are wholly wanting. In the female the wing covers are dark brown, about half the length of the abdomen, and have many rather coarse, whitish, parallel veins; whereas in the male they are light brown, reach to the end of the abdomen and have but few reticulated veins. There are usually three narrow, blackish lines on top of the head and one along each side of the prothorax, but all of these are sometimes very dim or wholly wanting.

These small crickets are omnivorous, feeding upon all kinds of decaying animal matter as well as upon living vegetation, freshly dropped cow dung being also especially attractive to them. When disturbed they are very difficult to capture, making enormous leaps with their stout hind legs, no sooner striking the ground than they are up again, even if not pursued, until they find a leaf or other shelter beneath which to take refuge.

From their enormous numbers, as well as from the fact that they are constant, greedy feeders from the time the eggs hatch in spring until laid low by the hoar frost of autumn, it follows that they must be classed among our most injurious orthoptera, but as yet no effective means for their destruction have been discovered.

Mr. S. H. Scudder, in an article entitled the "Songs of the Grasshoppers," has given the following pleasing account of the sounds made by this species: "The chirping of the striped cricket is very similar to that of the black field cricket; and may be expressed by *r-r-r-u*, pronounced as though it were a

French word. The note is trilled forcibly, and lasts a variable length of time. One of these insects was once observed while singing to its mate. At first the song was mild and frequently broken; afterwards it grew impetuous, forcible and more prolonged; then it decreased in volume and extent until it became quite soft and feeble. At this point the male began to approach the female, uttering a series of twittering chirps; the female ran away, and the male, after a short chase, returned to his old haunt, singing with the same vigor but with more frequent pauses. At length finding all persuasions unavailing, he brought his serenade to a close."

Average measurements: Length of body of male, 9 mm.; of female, 12 mm.; of hind femora, 9 mm.; of ovipositor, 9 mm.

8. *NEMOBIUS EXIGUUS*, Scudder. The Lesser Striped Ground Cricket.

Nemobius exiguus, Scudder, Boston Jour. Nat. Hist., VII, 1862, 429,
(Not *Acheta exigua*, Say.).

Nemobius fasciatus exiguus, Fernald, Orth. N. Eng., 1888, 16.

Also a very common species and found in company with the preceding, the habits of the two being essentially the same. From *vittatus* it may be known by its *much smaller* size, lighter color, and by the last two segments of the maxillary palpus being white. Moreover the ovipositor is much shorter, being only one-half to two-thirds the length of the hind femur, whereas in *vittatus* it is fully as long as that segment. A careful examination of a large number of specimens leads me to believe that these differences are constant, with no intermediate forms, hence the two species should be separated.

Length of body, male, 7 mm.; of female, 8 mm.; of hind femora, 6 mm.; of ovipositor, 3 to 4 mm.

9. *NEMOBIUS FASCIATUS*, DeGeer. The Long-winged Striped Cricket.

Nemobius fasciatus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 436.

Fernald, Orth. N. Eng., 1888, 16.

McNeill, Psyche, VI, 1891, 6.

This species has not been seen by the writer within the boundaries of the state; but Scudder, *loc. cit.*, says that it has been taken at Delphi, Indiana. From the two preceding species it may be known by the presence of the inner wings, which extend beyond the end of the ovipositor. McNeil, *loc. cit.*, records it as being common about the electric lights at Rock Island, Illinois.

V. ANAXIPHUS, Saussure (1874).

Our native species of this genus are very small crickets resembling those of *Nemobius* in form of body, breadth of head, etc.; but having the ovipositor very much compressed and curved strongly upwards as in many of the common species of *Locustidae* or katydids.

10. ANAXIPHUS PULICARUS, Saussure.

Anaxipha pulicaria, McNeill, Psyche VI, 1891, 6.

Head and pronotum brick red in color, sparsely clothed with long hairs; wing covers and legs very light brown; abdomen and ovipositor darker. Both sexes are wingless, but the wing covers of the male are well developed, fully covering the abdomen, while those of the female reach but little beyond its middle. The cerci are exceedingly long, tapering, and covered with fine yellow hairs. The hind femora of the males are proportionally much longer than those of the females as will be seen by the following measurements:

Length of body—male, 6.5 mm., female, 8 mm.; length of posterior femora—male, 6.5 mm., female, 6 mm.; length of ovipositor, 3.5 mm.; of antennæ of male, 32 mm.

This handsome little cricket was first taken in the state on Aug. 26, 1891, at Kewanna, Fulton county, where it occurred in small numbers among the sphagnum mosses growing in a tamarack swamp. On Sept. 6, it was found in Vigo county, 135 miles farther south, about the borders of a large pond. Here it was abundant in isolated spots on the leaves and stems of the arrow alum, *Peltandra undulata*, Raf. It is very active and difficult to capture, and, on account of its small size, is doubtless overlooked in many localities where it occurs in abundance. It is not described in any of the works to which I had access, and specimens were sent to Prof. Lawrence Bruner, Lincoln, Neb., who kindly identified them for me.

VI. PHYLLOSCIRTUS, Guerin. (1846).

The members of this genus are small crickets which have the head broader than the prothorax. They may be readily known from all other Gryllids by having the apical joint of the maxillary palpus flattened, oval, and much longer than the preceding joint which is triangular. The ovipositor is somewhat compressed and curved upwards.

11. PHYLLOSCIRTUS PULCHELLUS, Uhler. The Handsome Cricket.

Phyllopalpus pulchellus, Uhler, Proc. Ent. Soc. Phil., II, 1864, 544.

Phylloscirtus pulchellus, Riley, Stand. Nat. Hist., II, 1884, 183.

McNeill, Psyche, VI, 1891, 6.

This is the only species of the genus known to occur in the eastern United States, and is the most brightly colored of all our native crickets. In the living specimen the head and thorax are crimson, the wing covers a shining pitch black, while the thick hind femora are almost transparent but become white in alcohol. The wing covers reach the end of the abdomen, and the wings are almost as long. A single female specimen was taken on September 6th, from a leaf of the button bush, *Cephalanthus occidentalis*, L., near the border of a large pond in Vigo county. When discovered it was motionless, but was vibrating its large maxillary palpi in a very rapid and curious manner. It is a southern species but has been recorded from New York and Illinois, and probably occurs in low wet woods throughout the southern half of this state. According to Uhler, it is found most frequently "amongst the grass and low bushes near ditches where it jumps about with great rapidity."

Measurements: Length of body, 8.5 mm.; of ovipositor, 3.5 mm.; of posterior femora, 6 mm.; of antennæ, 18 mm.

VII. OROCHARIS, Uhler (1864).

The members of this genus have the head slightly narrower than the base of the pronotum; the maxillary palpi with the third segment longest, cylindrical; the apical one a little longer than the one preceding, enlarged gradually from the base, obliquely truncate. Both wing covers and wings are longer than the abdomen. The posterior femora are less thickened and the body less robust, longer, and flatter, than in the preceding or the following genus.

12. OROCHARIS SALTATOR, Uhler.

Orocharis saltator, Uhler, Proc. Ent. Sec. Phil., II., 1864, 545.

Riley, Stand. Nat. Hist., II, 1884, 182.

Apithes McNeillii, Blatchley, Canadian Entomologist, XXIV, 1892, 27.

General color, after immersion in alcohol, dull brownish yellow, the male the lighter. A dark brown stripe reaches from the eye along the side of head and prothorax to posterior border of pronotum. The wing covers each with a small brown spot at base; those of the female with many cross veinlets which are darker than those running lengthwise, giving the dorsal field a checkered appearance. In the male the vein separating the dorsal field of the wing cover from the lateral is yellow; in the female the yellow is broken by a number of oblong dark spots. All the femora are rather thickly marked with small, dark spots; those on the posterior pair

being arranged in regular rows. The wings extend 2.5 mm. beyond the tip of wing covers. Measurements: Female, length of body, 16 mm.; of wing covers, 14.5 mm.; of posterior femora, 9 mm.; of ovipositor, 12 mm. Male, length of body, 14 mm.; of wing covers, 12.5 mm.; of posterior femora 7.5 mm.

A single pair have been taken in Vigo county. The female was secured Oct. 21, 1891, from the lower leaves of a golden rod, *Solidago latifolia*, L., which grew in a thick, upland woods. The male was taken just a year later from the under surface of a leaf of prickly ash, *Xanthoxylum americanum*, Mill. It flew from one leaf to another and, before its capture, was thought to be a species of *Blattidæ*, so flat did its body appear.

Not having Mr. Uhler's paper when the female was taken it was sent to Mr. S. H. Scudder, of Cambridge, Mass., for identification. He returned it with the statement that it was, in his opinion, "an undescribed species of *Apithes*, allied to *A. azteca*, Sauss, and very different from *A. quadrata*, Scudder." On the strength of his statement, and prematurely on my part, it was described as new in the Canadian Entomologist, *loc. cit.* Having since secured Mr. Uhler's paper diagnosing the two genera, *Apithes* and *Orocharis*, a careful comparison with the descriptions therein proves it to belong to the latter genus; and, although differing somewhat in the details of color and measurement from Uhler's description of *saltator*; yet the differences are not sufficient, in my opinion, to make of it a distinct species. It has heretofore, been recorded, as far as I can ascertain, only from the southeastern United States.

VIII. APITHES—(HAPITHUS), Uhler (1864).

Thick bodied crickets resembling in general form the members of the genus *Gryllus* but having the head narrower than the posterior margin of the pronotum. The maxillary palpi with the apical segment as long as the 2d and 3d together. The wing covers do not reach the base of the abdomen and the wings are much shorter.

13. APITHES AGITATOR, Uhler.

Hapithus agitator, Uhler, Proc. Ent. Soc. Phil., II, 1864, 546.

Riley, Stand. Nat. Hist., II, 1884, 183, fig. 258.

A short, heavy-bodied cricket; dull reddish brown in color, with the vein, separating the dorsal field of the wing cover from the lateral, a yellowish white. The top of head and pronotum, and the surface of all the femora densely covered with brownish-yellow hairs. Measurements: Female, length of body, 11 mm.; of wing covers, 7.5 mm.; of posterior femo-

ra, 9 mm.; of ovipositor, 8 mm. Male, length of body, 10 mm.; of posterior femora, 8 mm.

A large number of specimens of this cricket were taken in two localities in Vigo county, Indiana, during the last half of September. The first ones discovered were on the slender twigs of some prickly ash shrubs which grew in a damp upland woods. The place was visited a number of times and the crickets were always found, perfectly motionless, and immediately above or below one of the thorns or prickles jutting forth from the twigs. The tips of the hind femora were raised so as to project above the body thus causing them to resemble the thorns; and the color of the insects corresponding closely to that of the bark, made them very difficult to discover even when in especial search of them. On every clump of prickly ash in the woods mentioned a number of specimens were secured but they could be found no where else thereabouts. The second locality where they were discovered was about the roots of a scarlet oak, *Quercus coccinea*, Wang, which grew on a sandy hillside. Here they were plentiful, and resting motionless in the depressions of the bark or beneath the leaves in the cavities formed by the roots of the tree.

Of all the males taken, over thirty in number, there was not one with perfect wing covers, and, in almost every instance, the wing covers as well as the rudimentary wings were wholly absent; while every female had both pairs unharmed. I at first ascribed this wing mutilation to the males fighting among themselves, but finally discovered a female in the act of devouring the wings of a male. Why this curious habit on the part of the one sex? Possibly the females require a wing diet to requite them for their bestowed affections, or, perchance, they are a jealous set, and, having once gained the affections of a male, devour his wing covers to keep him from calling other females about him. *Quien sabe?*

Agitator is said to be common in the middle and southeastern states. The eggs of the female are there deposited in twigs of the white elm, *Ulmus Americana*, L., and the insects are very active at night, running and jumping about on the trunks of various trees.

IX. *ECANTHUS*, Serville (1831).

From the other *Gryllidae* of the state the members of this genus may be known by their slender hind femora, their narrow, elongated prothorax, and their whitish or greenish-white color. The wing covers of the females are wrapped closely about the body, while those of the male are much

firmer in texture, broadly spread out, and very transparent; causing such a difference of appearance between the two sexes that tyro collectors often take them for widely different insects. Three species have, so far, been collected in the state, and two others very likely occur, but have not yet been taken.

14. *ECANTHUS NIVEUS*, DeGeer. The White Climbing Cricket.

Ecantus niveus, Harris, Ins. Inj. Veg., 1862, 153, figs. 71, 72, (In part).

Fitch, Third Rep. Nox. Ins., N. Y., 1856, 86.

Scudder, Bost. Journ. Nat. Hist., VII, 1862, 431.

Rathvon, U. S. Agr. Rep., 1862, 381, figs. 17, 18.

Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 444.

Walsh, Prac. Entom., I, 1866, 126; II, 1867, 54, 94.

Scudder, Dist. Ins. in N. H., 1874, 365, (Note of, set to music).

Glover, U. S. Ag. Rep., 1874, 143, fig. 16.

Packard, Guide Stud. Ins., 1883, 564, figs. 561, 562.

Id., Rep. U. S. Ent. Conn., V, 1890, 230, 591, figs. 75, 76.

Fernald, Orth. N. Eng., 1888, 17, figs. 7, 8, 9.

Comstock, Intr. Ent., I, 1888, 122, figs. 109, 110.

Murtfeldt, Insect Life, II, 1889, 130, (Carnivorous habits of).

McNeill, Psyche, VI, 1891, 6.

Both sexes of this species are in color ivory white, more or less tinged with a delicate green, especially in the female. The top of head and basal joint of antennæ are usually suffused with ochre yellow, while on the lower face of each of the two basal joints of the antennæ is a small black spot. The ovipositor of the female is short, perfectly straight and usually tipped with black. The maxillary palpi are longer in this than in any other species of the genus and the wing covers of the male are broader in proportion to their length than in any other except *O. latipennis*, Riley.

Measurements: Male, length of body, 13 mm.; of wing covers, 13.5 mm.; width of wing covers, 6.5 mm. Female, length of body, 14.5 mm.; of wing covers, 14 mm.; of ovipositor, 5.5 mm.

The white climbing cricket is very common throughout the state, and mature specimens are to be found in numbers about grape vines, shrubbery, etc., from August 1st till November. In my experience the females appear more plentiful than the males, the latter being more often heard than seen.

During the day they keep themselves hidden among the foliage and flowers of various plants, but as night approaches they come forth and the male begins his incessant, shrill, chirping note, which he continues with little or no intermission till the approach of morning warns him to desist. Prof. McNeill, in *Psyche*, *loc. cit.*, has given an excellent description of the songs of the different species of *Oecanthus*. "That of *niveus*," he says, "is the well known *t-r-r—r-e-e: t-r-r—r-e-e*, repeated without pause or variation about seventy times in a minute. It is heard only at night and occasionally on cloudy days, but in the latter case it is only an isolated song, and never the full chorus of the night-song produced by many wings whose vibrations in exact unison produces that characteristic 'rhythmic beat,' as Burroughs has happily phrased it."

The females of *niveus* do much harm by ovipositing in the tender canes or shoots of various plants, as the raspberry, grape, plum, peach, etc.; no less than 321 eggs, by actual count, having been found in a raspberry cane 22 inches in length. The eggs are laid in autumn and at first the injury is shown only by a slight roughness of the bark, but afterwards the cane or branch frequently dies above the puncture, or is so much injured as to be broken off by the first high wind. If the injured and broken canes containing the eggs be collected and burned in early spring the number of insects for that season will be materially lessened.

Niveus, however, in part if not wholly, offsets this injurious habit by its carnivorous propensities, as the young, which are hatched in June, feed for some time upon the various species of aphides or plant lice which infest the shrubbery they frequent. Mr. B. D. Walsh, in the *Practical Entomologist*, *loc. cit.*, was the first entomologist to call attention to this carnivorous habit, but it seems little attention was given to the matter. Recently, however, it has come up again, and in *Insect Life*, for November, 1891, Miss Mary E. Murtfeldt, of St. Louis, Mo., has given a most interesting account of some experiments and observations concerning it which were made by her. From this article the following extract is taken: "Some leaves of plum infested with a delicate species of yellow aphid were put into a jar with the young of *Oecanthus niveus*, but attracted no immediate attention. As twilight deepened, however, the crickets awakened to greater activity. By holding the jar against the light of the window, or bringing it suddenly into the lamp light, the little nocturnal hunters might be seen hurrying with a furtive, darting movement over the leaves and stems, the head bent down, the antennæ stretched forward, and every sense apparently

on the alert. Then the aphides provided for their food would be caught up one after another with eagerness and devoured with violent action of the mouth parts, the antennæ meanwhile playing up and down in evident expression of satisfaction. Unless I had provided very liberally not an aphid would be found in the jar the next morning and the sluggish crickets would have every appearance of plethora."

15. *ÆCANTHUS FASCIATUS*, Fitch. The Striped Tree Cricket.

Æcanthus fasciatus, Fitch, Third Rep. Nox. Ins., N. Y., 1856, 96.

McNeill, Psyche, VI, 1891, 6.

Æcanthus niveus, Harris, Ins. Inj. to Veg., 1862, 154, (In part).

Rathvon, U. S. Ag. Rep., 1862, 381.

In its general form this insect resembles the preceding, but it is always darker in color, varying from a deep black to ivory white with fuscous markings. Most specimens, however, are greenish white with three black stripes on the head and pronotum and a broad dusky line along the center of the abdomen beneath. The wing covers of the male are less broad in proportion to their length than in *niveus*; while the ovipositor is longer and more distinctly turned upwards at the end than in that species.

Measurements: Male—Length of body, 14 mm.; of wing covers, 11.5 mm.; width of wing covers, 5.5 mm. Female—Length of ovipositor, 6.5 mm.

In Indiana this species is fully as common if not more so than *O. niveus*. It is more frequently found on wild plants than that species, being, in autumn, an abundant visitor of sun-flowers and golden rods. Mature specimens were taken in Putnam county, as early as August 9th.

16. *ÆCANTHUS ANGUSTIPENNIS*, Fitch. The Narrow-winged Tree Cricket.

Æcanthus angustipennis, Fitch, Third Rep. Nox. Ins., N. Y., 1856, 95.

McNeill, Psyche, VI, 1891, 8.

This species is readily distinguished by the narrowness of the wing covers of the male, their breadth being just about one third their length. The wings are longer than in either of the two preceding, extending in one specimen at hand, 9 mm. beyond the wing covers. The head and prothorax are less prominent, and the latter is much narrowed anteriorly. The general color is an ivory white, rather deeply tinged with greenish.

Measurements: Male—Length of body, 13 mm.; of wing covers, 11.5 mm. width of wing covers, 4 mm.

Angustipennis probably occurs in all parts of the state but is much less

common than either *niveus* or *fasciatus*. A fully developed male was taken from a leaf of an iron weed, *Vernonia fasciculata* Michx., on August 11th.

* * *

This completes the list of *Gryllidæ* so far known to have been taken in the state. Other species undoubtedly occur, and it was a desire to awaken an interest in the family and so lead, if possible, to their discovery, which, in the main, prompted the preparation of the present paper.

The species most likely to occur, but which have not, as yet, been noted are: *Tridactylus terminalis*, Uhler; *Tridactylus minutus*, Scudder; *Æcanthus latipennis*, Riley; *Æcanthus bipunctatus*, De Geer, and one or two species of *Myrmecophila*, which are the smallest crickets known. They resemble closely the young of cockroaches and inhabit the nests of ants. The writer will be pleased to receive specimens of *Gryllidæ* and other *Orthoptera* from any part of the state, and will return the names of those sent to all who may so desire.

BIOLOGICAL LABORATORY,

Terre Haute, High School.

ENTOMOLOGIZING IN MEXICO. By W. S. BLATCHLEY.

THE OUTLOOK IN THE WARFARE AGAINST INFECTION. By THEODORE POTTER.

OUR PRESENT KNOWLEDGE CONCERNING THE GREEN TRITON, *DIEMYCTYLUS VIRIDESCENS*. By O. P. HAY.

The green triton, or newt, *Diemyctylus viridescens*, has been before this academy for discussion at a previous meeting. Since that time there have been some accessions to our knowledge regarding it. This pretty and harmless newt probably inhabits all parts of the state, but I have not found it abundant anywhere, though no doubt it is plentiful in suitable localities.

It is quite common in the Eastern States, and has been studied a good deal by the naturalists there, to whom it has presented some interesting problems. It is interesting because of its position near the top of the order Urolela. *Salamandrina perspicillata*, of Europe, is very closely related to it; but since the digits of the hinder foot of that species are reduced to four, it must be regarded as standing higher than ours, which has five digits.

The newt has given the systematists a good deal of trouble, a fact resulting, as in so many other cases, from a lack of knowledge regarding its life-history. Formerly there were believed to be two entirely distinct species, the one living on the land and being of a red color, the other living entirely in the water and being of a general greenish color. Rafinesque, who first described these animals, placed the two forms under different subgenera. Baird saw that they must be included under the same genus, but regarded them as distinct species. Dr. Hallowell seems to have been the first to regard them as belonging to the same species. For a long time, in fact until very recently, they have been regarded as being varieties of the same species. A few observers have, within a few years, claimed to have seen the red land form transform into the aquatic stage, and some have thought that they saw indications of a change of the aquatic animal into the terrestrial form. Hence, it was supposed that the differences were due to seasonal changes. It was supposed that the animal went into the water to deposit its eggs, took on the characters peculiar to that state, and afterwards, when the breeding season was over, again sought the land and became red again.

At the 1891 meeting of the American Association for the Advancement of Science, at Washington, Prof. Gage, of Cornell University, read a paper which gave the results of his studies on this animal for some years. His conclusions, in brief, are that all the modifications that the animal undergoes belong simply to different stages in the development of one and the same individual. The eggs are laid in the water and hatched in due time. For some time the young have gills, like any other well regulated Urodele. When a length of about an inch and a half has been attained, they leave the water, having lost their gills, and betake themselves to the land. They then assume a red color, varying from orange to blood red, the tail becomes round and the skin usually rough. Here they appear to remain until they are about three years old, hiding under rocks and logs, and appearing after rains. When the season of sexual maturity arrives, they go again into the water, and, according to Gage's opinion, remain there the remainder of their lives, unless the pools dry up or food becomes scarce. Prof. Gage's

paper has appeared in the *American Naturalist* for December, 1891, illustrated with a colored plate.

During the past summer, before I knew of Prof. Gage's work on the newt, I attempted to solve the question about the two forms of the animal by a study of the specimens in the National Museum, about two hundred and fifty in number, and from all parts of the country. I reasoned that if there were two varieties of the animal we ought in a large collection to find them both in all stages of growth; if the red form was only the young stage of the animal then the green aquatic specimens ought to be all larger than the red ones. One of the first things that I discovered was that there was not a single character on which I could depend as a means of distinguishing the two forms. Neither redness, nor roughness, nor lack of tail-fin, belonged to the land form alone. Of some it seemed to be impossible to say with any certainty to which form they ought to be assigned.

Nevertheless it was apparent that the red or *miniatus* form reached a maximum length of a little over three inches, while the undoubted viridescent form ranged from a little less than three inches up to four or more. Yet a breeding male of the viridescent form was found to be only two and three-fourths inches long. On the whole, it seemed clear that at a certain stage the red, land form must enter the water and assume characters to some extent different from those possessed while on land.

As to the color of the aquatic form, olive is the prevailing tint. Yet many have more or less red mingled with it, and not a few are decidedly red. It is probable that none of those which have betaken themselves to the water are as scarlet as those living on the land, yet they must come pretty near it. As to the purpose of the coloration assumed in the water, it is not difficult to see that it will be highly protective to an animal that dwells amid green vegetation; but why the land-dwellers should be so conspicuously red is not so easily decided. No concealment seems to be sought here. It is possible that the land form is a distasteful morsel to such animals as it comes in contact with, and the color is developed as a warning signal. Those who have the opportunity to experiment with them ought to endeavor to settle the question. The salamanders are given to eating all such animals, and the red young of the newt might be offered to *Ambystoma tigrinum*, for instance, in order to determine whether or not the latter would eat the young newt.

There are some interesting matters connected with the size of the larva at the time of the transformation. Prof. Gage states that he has never seen

a larva at this period less than three centimeters long or more than four, while some of the bright red ones are only five centimeters long, that is, two inches. Now in the national collection I found larvæ yet with remains of gills, and some of these larvæ were two and three-fourths inches long. These were from Jersey City, N. J. Not long ago Prof. Gage sent me a specimen for examination, which he had taken at Wood's Holl, and this one is fully as large as those I have mentioned. The smallest red specimens mentioned by Prof. Gage are two inches long. Some of the red specimens seen by me at Washington were only an inch and a half, an inch and three-quarters, and one only an inch and five-sixteenths long. Here we have evidence of very great variation in the size of the larvæ at the time of transformation. I believe also that there is, during the transformation, a considerable shrinkage in the size of the whole body. Such shrinkage occurs during the transformation of *Ambystoma microstomum*, and probably of most salamanders.

Thus, while we are gradually getting at a correct knowledge of this interesting animal, the green triton, or newt, it is a good subject for further study.

THE PROPER SYSTEMATIC NAME OF THE PRAIRIE RATTLESNAKE. By O. P. HAY.

THE BLIND CRAYFISHES OF INDIANA. By W. P. HAY.

THE CRUSTACEA OF INDIANA. By W. P. HAY, M. S.

The following list of the crustaceans of Indiana is to be regarded as a first contribution to the knowledge of this interesting group. Although it represents the labor of quite an extended period, the labor was confined mostly to the central part of the state, and to the larger forms; and there still remains the great multitude of microscopic forms only a few of which are here numbered. It is for the purpose of directing the attention of the

Indiana Academy to this interesting and much neglected part of our fauna that this paper is written.

Cambarus argillicola Faxon. Very common in central Indiana. It is very similar, both in appearance and habits, to its near relative, *C. diogenes*. Like this latter species, *C. argillicola* burrows and raises mud chimneys at the mouth of its hole. It is apparently of smaller size than *C. diogenes*, the largest specimen measuring barely 2½ inches from the rostral spine to the end of the tail. The bearded head spoken of by Dr. Faxon in his monograph is hardly a constant feature. Indeed, of all the specimens which have come under my notice at least half, without distinction as regards sex, were without the beard. The eggs are laid in the early spring, often, it seems, before the females retire to their burrows. A small female bearing eggs was taken from a pond April 2, and a female with young was dug from a burrow April 20. The burrows were excavated in the tough clay, near a pond, to a depth of about 2½ feet.

Cambarus bartonii Fabricius. This species will probably be found to occur throughout the state. It is much more common, however, in rocky localities than elsewhere. It is a cave-loving species, occurring in nearly every one of the caverns of southern Indiana. I have often observed both it and *C. pellucidus* in the same cave.

Cambarus blandingii Hagen. A number of specimens from English Lake seem to be this species, though they may be the following, which is reported by Dr. Faxon.

Cambarus blandingii var. *acuta* Faxon. This species is reported from Wheatland, Knox county.

Cambarus diogenes Girard. In early spring this is the most conspicuous crayfish, both by its abundance, large size, and fine coloration. The females far surpass any other species in the different colors, which are beautifully blended. As they are strictly a burrowing species, they are to be found only during the breeding season, which begins about the first of April. At this time they are very common, even in the daytime. At night they are abundant. Thirty-five large specimens were collected in one evening, April 2, 1892. Of this number twenty-nine were males and six females. A number of females found in copulation were separated from the rest to observe the time elapsing before the eggs were laid. The first eggs were laid April 18, while another specimen of the same lot, with well developed but unlaid eggs, was killed and dissected April 20.

After the breeding season they retire to their burrows, and for the rest of

the year their presence is known only by the chimneys which they raise over the mouth of the holes.

Cambarus immunis Hagen. This species is exceedingly abundant during the summer in muddy ponds. They burrow into the mud on the drying up of the ponds. I have never observed them in running water.

Cambarus pellucidus Tellkamp. The common blind crayfish occurs in many of the caves of southern Indiana. They are usually small, the largest I have ever seen, among 40 specimens, being barely 2 inches in length. They are kept from extinction only by the inaccessibility of their home. They are very conspicuous when in the water, and are very easily caught. When startled they are utterly at loss where to go, and often dart out upon the shore. I think it may be safely said that as a rule they grow spinier as one advances southward, although there are exceptions. A female collected in Wyandotte Cave is almost without spines; but three specimens from a small cave near there are exceedingly spiny.

Cambarus pellucidus var. *testii* Hay. This crayfish, although at first thought to be a distinct species, is probably only a variety of the preceding, characterized by the entire absence of spines. There are no teeth on the rostrum or spines on the sides of the carapace, things never lacking in the common species. The type specimens, 12 or 13 in number, were collected in Mayfield's cave, near Bloomington. They have since been received from Truett's cave, in the same county.

Cambarus propinquus Girard. This is apparently the common species throughout the state. In the central portion it is very abundant at all seasons of the year, being almost invariably found in running water. The median carina on the rostrum, one of the characteristic marks of the species, may vary from a long ridge to a mere papilla-like elevation. The color in life is a dingy dark olive. The tips of the chelæ are sometimes red, and the spines on the rostrum brown.

Cambarus putnami Faxon. In his "Monograph on the American Astacidae," Dr. Faxon mentions the probability of this species occurring in the southern part of the state. I have specimens taken between Paoli and Wyandotte cave, in the summer of 1888.

Cambarus rusticus Girard. This species, which is very like *propinquus*, is tolerably common. It has been collected at Madison and at Indianapolis.

Cambarus sloanii Faxon. The only known locality for this species in Indiana is in the region about New Albany.

Cambarus virilis Hagen. Is very common and widely distributed in the northern part of the state. I have also found it at Irvington.

Palæmon ohionis Smith. The river shrimp has been taken in large numbers in the Ohio at Lawrenceburg. It will probably be found to occur in the lower Wabash and possibly some of the other large streams in the south of the state.

Allorchestes dentata Smith. This small crustacean was taken on one occasion from a small pool along Fall creek, north of Indianapolis. It has also been observed by Prof. S. A. Forbes in northeastern Indiana.

Crangonyx gracilis Smith. Very common in stagnant water in central Indiana. I have never observed it in the streams. Early spring is the best collecting time for this crustacean, as it then attains its largest size.

Crangonyx packardi Smith. I have not yet collected this species, but it is said to be common in the southern portion of the state.

Crangonyx mucronatus Forbes. This interesting species, I think, will be found to occur over a large portion of Indiana. I have found it under logs in a swamp near Irvington, have taken it from at least one well in the vicinity, and have observed and collected it in nearly every cave in Monroe, Lawrence, Crawford and Harrison counties.

Mancasellus tenax Harper. An exceedingly large and abundant species which may be found in early spring in the water courses. I have often observed it in stagnant water, but in running water, as at the mouth of a tile drain, they may be collected by the hundreds.

Asellus communis Say. This species appears to take the place of the preceding species in the ponds. I have rarely observed it in running water, but in early spring it is very common in the ponds about Indianapolis.

Asellus stygius Packard. This interesting blind *Asellus* I have found in two wells, three or four miles north of Irvington. It is also very common in the caves, but does not appear to grow to so large a size as those taken from the wells.

Scyphacella putan W. P. Hay. This very curious and remarkable crustacean is as yet undescribed, but is here included. The type specimens were obtained from a well in Irvington. Soon after the specimens were taken the well was cleaned, and no crustaceans have been observed since. Its nearest relative is *Scyphacella arenicola*, a salt water crustacean.

Branchipus vernalis Verrill. In the central portion of the state, about Irvington, this beautiful crustacean is very abundant. In one sweep of the

net I have taken over a hundred of them. It has also been taken at Bloomington, Ind.

Branchipus gellidus W. P. Hay. Abundant at times about Irvington. It was described February, 1883, in the American Naturalist, from specimens collected in the early spring of that year. On the drying up of the ponds it disappeared, and although careful search was made every winter after, it was not seen again till April, 1892, when it was again found to be common. It is much smaller than *B. vernalis*, and seems to congregate in little groups of 15 to 20. They are very delicate and die soon after capture.

Euphiloscia elrodi Packard. This is the only "sow-bug" described from the state, although several species are common.

Diaptomus sanguineus Forbes. At times so common as to give the pond water a pinkish color. I have observed it only about Irvington.

Daphnia rosea Sars. Very abundant, in company with other species, in ponds about Irvington.

Ceriodaphnia quadrangula. Common, in company with other species, in ponds about Irvington.

Ceriodaphnia cristata Birge. Occurs frequently with the two preceding species.

Cyclops parvus Herrick. Collected from ponds about Irvington.

Cyclops insectus Forbes. Collected from ponds about Irvington.

It will be seen that so far thirty-one species of crustaceans have been collected from the state. A little careful search would doubtless more than double the number.

NOTES ON ELAPS FULVUS. By A. J. BIGNEY.

About two years ago a very beautiful snake was taken to the drug store of V. W. Bigney, at Sunman, Ripley county, Indiana; it having been found near Milan, in the same county. It was preserved in alcohol and a little more than a year ago it was sent to me for identification. After carefully examining it I pronounced it to be the *Elaps fulvius*, or bead snake, belonging to the order of the Harlequin snakes.

A careful study has revealed some interesting facts. The order to which this snake belongs is very widely distributed, being found not only in North America but also in Southern Asia, Australia, South America, and the isles

of the sea. The warmer regions are their regular home. In the United States it is found in Virginia, Georgia, Florida, Texas, Arizona, New Mexico, and Arkansas. No mention is made of its being found further north than Virginia and Arkansas. Only one species inhabits North America, but there are several varieties, distinguished chiefly by the arrangement of the colored bands. This snake is ordinarily found in the ground in sweet potato fields. The question naturally arises, How came it so far north? Has it ever been found in this state before? Was it carried here and escaped? I am rather inclined to the latter view. If, however, it has been found in this state by other parties, then this view is evidently erroneous.

The specimen under consideration is about 25 inches long. It has more than 200 gastrostoges, which are entire, and the urostoges bifid. The anal plate is also bifid. Dr. Jordan, in his "Manual," speaks of it as being entire. This is evidently an exception to the rule, and this plate is, therefore, somewhat variable. The snake has seventeen bands of crimson, bordered by yellow. The occipital band is yellow and the bands on the tail also have no red. It has no loreal plate, but in another species it is present. It has two fangs in the upper jaw, which are hollow, and on the front side there is a permanent groove; back of these fangs are small teeth. The *Elaps fulvius* is classed among the venomous by Dr. Jordan. If any one has found another specimen in the state I shall be glad to learn of it.

SOME OBSERVATIONS ON *HELODERMA SUSPECTUM*. By D. A. OWEN, Moore's Hill College.

About the middle of last May the museum of Franklin College came into possession of a fine specimen of *Heloderma suspectum* or "Gila monster," from Sacaton, Arizona. This is one of the largest of lizards, and the only one in America reputed venomous.

The specimen received is eighteen inches long from the tip of his snout to the end of his tail, which is six inches long and of an uniform diameter of about one inch and a half until within a short distance of the end, where it terminates in a blunt point.

The body is beautifully marked by black and flesh colored tubercular scales, much resembling Indian bead work. Its habits are very sluggish,

and not infrequently whole days are spent in sleeping. This is almost universally the case during very cloudy weather. Its food has consisted of raw eggs, of which three or four are consumed in a week. Sometimes it will eat an egg each day for two or three days, and then will touch nothing for nearly a week. The method of taking this food is by suction, assisted by sliding back and forth its flat, forked tongue. When the eggs were given without first breaking the parts, it was very difficult to swallow, the food would be forced out through the nostrils and some time would be spent holding the head elevated so that gravity might force it down the throat.

Other foods were offered, but in no case were they touched.

Although its native home is in that arid region where rain seldom falls in abundance, it showed a special fondness for water. It would frequently lie in a pan of water during the whole day. At times, when the appetite made no demands for the food, he would frequently crawl into the pan, as if he preferred to take it by absorption.

In breathing, there seemed to be a full expansion of the lungs every 50 or 60 seconds. The air is then expelled, as it seems, in a kind of pulsations. These pulsations are seen on each side of the neck and vary from fifteen to thirty per minute. But during the torpid state, which began about the middle of October, there appears to be no full expansion of the chest, but respiration is conducted wholly by this pulsation. If, however, the animal be disturbed, the air is immediately forced out of the lungs with a sound very much resembling a deep sigh.

The moulting began about the last of July or the first of August, and was not completed until the last of September. The skin was removed in pieces, beginning about the middle of the body.

In regard to the nature of the vermin and the fatality of the bite there is little to offer that is new. The result of experiments, however, seem to cast some doubt upon the idea formerly held that the action of the poison was very rapid.

The first animal that was bitten was the common tiger salamander. In this case there was no more deleterious effect than would have occurred from the bite of any other animal. The same thing was true with the next, which was a common toad. In both of these cases, after the bite, the heloderma frothed considerably at the mouth and refused to make the second bite.

The next animal bitten was a rat. After the rat had been bitten two or

three times, with seemingly no perceptible effects, it was taken out and placed in a cage with a rattlesnake, where it was bitten twice, and within the space of two hours was dead. A second rat, after an absence of a few days, was put in with the heloderma and was bitten three times; once upon the fore leg, and once upon the tail, and again through the lower jaw. The first two bites occurred before nine o'clock in the morning, the third about one in the afternoon. At four o'clock the same day the rat seemed all right, with the exception of being cowed and having a desire to get as far from the lizard as possible. The next morning, upon observation, the rat was found dead, and when picked up a greenish fluid ran out of its mouth.

* The heloderma, when undisturbed, is a harmless individual, and at no time was its biting voluntary. But when disturbed he elevated his head with mouth open, giving forth the aspirate sound of *hah*, and if at this time any thing is placed within his open mouth, the jaws immediately close upon it. The biting is simply holding fast for a few minutes. There are no fangs in the upper jaw, as in the rattlesnake, and if there be any poison it must be from the ordinary saliva and depends upon the degree of irritation of the animal.

Judging from the actions of the two rats bitten, one by the snake and the other by the lizard, we believe the poison in the two reptiles acts differently. From the death struggles of the one bitten by the rattlesnake there appears to be a paralysis of the respiratory organs, while from the stupor which appeared to take hold of the other, we judge in that case to be a paralysis of the circulatory organs.

SOME OBSERVATIONS ON PHOTOMICROGRAPHY. By D. W. DENNIS.

CONTRIBUTIONS TO A KNOWLEDGE OF THE GRAIN TOXOPTERA (TOXOPTERA GRAMINUM). By F. M. WEBSTER.

BUFFALO GNATS (SIMULIDÆ) IN INDIANA AND ILLINOIS. By F. M. WEBSTER.

In his "Guide to the Study of Insects," p. 391, and again in his "Our Common Insects," p. 73, Dr. A. S. Packard acknowledges the receipt of examples of a buffalo gnat from Prof. J. T. Cox, State Geologist of Indiana.

In this notice it is not stated whether the examples were taken in Indiana, or in Illinois, where the author accuses the insect of causing the death of horses on the prairies.

The late Dr. E. R. Boardman, of Stark County, Illinois, wrote me some years ago of the former occurrence of these gnats in his State, as follows: "I spent the summer of 1843 here on Spoon River. The settlers used to watch for the appearance of the buffalo gnats every year, and they usually came from the 10th to the 20th of May, from the Winnebago Swamp. That year it was about the 12th or 15th of May, when we were planting corn, that a neighbor rode up and told us to look to our stock, as the gnats were coming. In less than an hour the cattle and horses came tearing in off the prairie, the former bellowing with pain, the latter kicking and throwing themselves on the ground, and rolling to rid themselves of their tormentors. The gnats did not usually remain more than four or five days at the longest, and often not over twenty-four hours, when a wind would carry them off.

"When they used to come in such numbers, I have known them to run stock from here, thirty or forty miles down the Henderson River, and when the stock were recovered they would be so used up by running as to be almost useless. The deer used to leave the swamps about the time the gnats appeared, and take shelter along Spoon River, often coming in droves, and when hard pushed would take to the water.

"The gnats came more like a swarm of bees than anything else I can compare them to. I never saw them at Pawpaw, DeKalb county, nor do I recollect of seeing or hearing of their occurrence here, for the last thirty years—since the swamp has been drained and pastured."

The following, from a letter received several years ago from Mr. John Marten, at that time residing in Decatur, Illinois, will give additional information as to the distribution of *Simulium* in Illinois, and also add a valuable hint as to remedial measures for the relief of stricken animals.

"I have found the buffalo gnat in Edwards county, Illinois. In the spring of 1883 or 1884, I do not now remember which, two, and possibly more, horses were killed in that county. During both seasons the gnat was found there. Farmers from Richland and Lawrence counties, north of Edwards,

complained of the pest. My observations were too limited to say more than these general things.

"My father-in-law, before his death, told me that in former years the gnats had been very troublesome in Edwards county, and that whenever he had been called upon to treat cattle or horses they always recovered. He condemned, roundly, the notion that the bites of the gnats were necessarily fatal, saying that cures could easily be made by such treatment as would cause copious urination. He used nitrates and kindred remedies. He was a practicing physician and thoroughly acquainted with his profession.

JOHN MARTEN."

Owing to the obscurity regarding the locality from which Prof. Cox obtained his specimens, it was not until the year 1886 that we had any exact information as to the occurrence of the buffalo gnat in Indiana; our attention being called to the fact by Prof. S. B. Boyd, of Washington, Davies county, who informed us that these insects occurred along White River in considerable numbers. With a view of gaining further information respecting this matter, we addressed a letter to Hon. Samuel Hargrove, of Union, Pike county, from whom we received a reply, not only corroborating Prof. Boyd, but stating the fact of their occurrence along the Patoka River, also.

On the 10th of November, 1886, we started on a trip to Pike county and vicinity, by way of Seymour, Jackson county, where we were informed by Mr. J. A. Peters, an extensive farmer of the bottom lands, that no gnats occurred in that vicinity, but about Bloomfield and Worthington, in Greene county, they often annoyed stock greatly. From Seymour we went to Washington, Davies county, where we again met Mr. Boyd, and learned from him that these gnats infested the bottom lands along the entire western, and also a portion of the southern, borders of that county.

In White county we examined a portion of the Patoka River, a small stream whose winding course is nearly due west, emptying its waters into the Wabash River a short distance below the mouth of the White. The bottoms are wide, and the bed is of clay, the current in low water, as it was at that time, is rather sluggish, but in high water it is quite swift and covers the bottoms, which are often cultivated, but fully as often timbered and grown up with brush. The stream also has more or less drift-wood, stumps, and other debris in it, but we found no place where this caused any perceivable increase of the current. We examined such of this drift-wood as we could disengage, but could find no trace of the buffalo gnat in any stage of development.

We learned from people residing along this stream, that in 1882 the gnats occurred as far up as Jasper, Dubois county, and several mules and horses, in the vicinity of Bovine, Pike county, died from the effects of being bitten by gnats. Usually, however, the insects did not occur in that vicinity in any considerable numbers.

At Hazleton, on White River, in Gibson county, Dr. P. H. Curtner informed me that gnats had appeared, with more or less regularity, every season for the last seventeen years, being very much more abundant in seasons of high water during spring time. Localities between Hazleton and the Wabash River were especially noted for the great numbers of gnats occurring there. Dr. Curtner's facts are of especial value, as he has had several years' experience with buffalo gnats in Louisiana, during the war, having been connected with a battery of Federal artillery.

A quite significant fact was noticed, in that wherever the insects were reported as being the most abundant, the stream was very tortuous, thereby presenting many narrow points of bottom-land, more or less covered with trees and underbrush, across which the water flows whenever the stream is very much swollen. Lumbermen, who are much on the river, say that where the bottoms have been cleared, gnats are not usually abundant.

Like the Patoka, White River has rather a sluggish current. At Hazleton, the latter is estimated to flow at the rate of about six miles per hour in ordinary high water; during low water it is much less.

The following letter adds much to a knowledge of the distribution of buffalo gnats in southwestern Indiana:

"MARCO, IND., December 21st, 1886.

"MR. F. M. WEBSTER, DEAR SIR:—I am somewhat acquainted with buffalo gnats. I first find them on the head waters of a stream called River Deshee, and also on Wilson Creek, in the southern part of Harrison township, Knox county, southeast of Vincennes. They are not so much in the White River bottoms as they are in the low, marshy land adjoining said bottoms. I find them in said township, further north, in the vicinity of a low, sluggish creek, called Pond Creek. Where the high lands come near the river, I find none until I get above Edwardsport, at the mouth of Black Creek: but following that creek in Greene county, I find them abundant in low, wet land that makes and adjoins said creek, to-wit: Cain Drain, or Delaware Creek, a large marsh in Knox county, Carico Marsh, the Goose Pond, Bee Hunter Marsh, and Ladies' Creek Marshes, all in Greene county. In the bottoms, on the west side of White River, you will find plenty of them; but above Worthington they have never been known, so far as I have heard.

"The buffalo gnat in his natural state is about one-half as large as the common house fly. They make their appearance in early spring. A few days,—with the temperature from forty to fifty degrees—is apt to bring them. They cannot exercise when the temperature is 32°, but will come immediately upon the weather's getting warmer. Rain and wet weather will down him for awhile. His life varies as to the weather. One week of clear weather, with the temperature from 70 to 80 degrees, ends his existence. Generally they last from four to six weeks. They are very severe on all kinds of stock, and run the cattle and hogs, and drive them to the open ground, where the wind and hot sun has a tendency to drive the gnats down. They have been known to kill horses by blood sucking, and, when full of blood, are about as big as two house flies. They never attack a man.

"As a preventive, we use coal oil, rubbing it on the horse's head, neck, breast and flanks, as these are the parts generally attacked.

"Yours truly,

DR. R. A. J."

At least two species of *Simulium* occur in the Wabash River, near New Harmony, Posey county, in what is known as the Cut Off. This cut off has existed since before the country was settled, though, in an earlier day it was much narrower and used as a mill race, an oil painting by LeSuer, showing it as it appeared at an early day, is yet in possession of a son of Robert Dale Owen, residing at New Harmony. The channel has widened of late years, the bottom being rocky as of old, and at the lower extremity filled with rocks and boulders, over and among which the water flows very swiftly. A number of head of stock were killed by gnats in this vicinity in 1884, and they were quite troublesome in the spring of 1890. On June 12th of the latter year I caught adults in the vicinity, belonging, without much doubt, to *Simulium pecuarum*, Riley, and feel quite sure that *S. meridionale*, Riley, also occurs there. From the number of pupa shells that, at the time of my visit, were attached to willows and branches of trees which had been inundated in spring, I judge that adults had been quite numerous. Larvæ were also found in the swifter flowing portions of the stream, but in limited numbers.

It appears somewhat strange that the only species of *Simulia* described by Thomas Say, for a long time a resident of New Harmony, should be accorded to Ohio, his specimens being from Ohio Falls, near Louisville, Kentucky. It would now appear almost impossible that they should not have inhabited the lower Wabash, while he was engaged in his entomological labors and within sight of the locality where they now occur. An almost parallel case is found in the chinch bug, which Say described in 1831 from

a single specimen "taken on the east shore of Virginia," while Prof. S. A. Forbes, in 16th Report of the State Entomologist of Illinois, p. 50, gives what seems to be incontrovertible proof that the insect was abundant in Illinois, within a few miles of New Harmony, as early as 1823. Therefore it does not seem improbable that *Simulia* may not have occurred in the Lower Wabash, and the Little Wabash, in Illinois, even before Say's residence at New Harmony, though, in attempting to secure proof of this I have been less fortunate than Prof. Forbes, as none of the oldest inhabitants about New Harmony can remember of the occurrence of buffalo gnats, except during recent years.

At the field meeting of the Academy, at Richmond, Indiana, May 12, 1892, we found another location for these insects, in Indiana, this being at Elkhorn Falls, situated five miles below the city. The larvæ, which appear to be different from any I have collected elsewhere, were found clinging to the rock and also to the algæ which overhangs the falls. No adults were found at the time, and but few pupæ.

THE DEVELOPMENT OF THE VIVIPAROUS FISHES OF CALIFORNIA. By CARL H. EIGENMANN.

RECENT ADDITIONS TO THE ICHTHYOLOGICAL FAUNA OF CALIFORNIA. By CARL H. EIGENMANN AND ROSA S. EIGENMANN. Published in part in Proc. U. S. Nat. Mus. for 1892 and in part in the Annals New York Acad. Sci. for 1892.

[ABSTRACT.]

We have prepared an enumeration of the fishes occurring on the Pacific coast of America, north of Cerros island, and to the depth of 150 fathoms. The explorations of the U. S. Fish Commission steamer *Albatross*, during the last three years, have added a large number of species to those previously known from this region, and our own explorations have added about as many new forms from San Diego alone as were discovered by the *Albatross* along the whole coast included in the present paper. These additions,

as well as the extension of the habitat of many species, make the present list desirable.

Several forms have recently been discovered by the Albatross in deeper water. Most of these, however, have little relationship to the littoral fauna and the deeper water has not been sufficiently explored to warrant a list at the present time.

We have placed the dividing line between the littoral and the bathybial faunas of this region at 150 fathoms, because all of the genera so far recorded from this depth have representatives in the shallower water—fifteen to fifty fathoms. Some of the littoral genera, as *Sebastodes*, have representatives in deeper water, but this is not of general occurrence.

Cerros island is a convenient and natural southern boundary to this region. South of it few, if any, of the characteristic genera (*Sebastodes*, genera of *Embiotocidae*,) of this region are found. A number of southern forms extend further north, but the number has not been materially increased by our explorations at San Diego; on the other hand a large number of northern forms, or representatives of northern forms, which had not been found south of Point Conception, were added to the San Diego fauna. The California fauna has hitherto been divided into a southern and a northern at Point Conception. This division was the result of insufficient exploration, and the results mentioned above have made it evident that no definite boundaries can be assigned for a northern and a southern California fauna.

It is quite evident, and readily admitted, that the fauna of California is distinct from the Alaskan fauna, and the latter has been added for convenience and comparison only. But four of the species found at San Diego are also found in Alaska. The California fauna is characterized by the abundance of species of *Sebastodes*, of *Cottidæ* and of *Embiotocidae*. The last are entirely absent from Alaska, while only a few species of *Sebastodes* are found here. The boundary between these two regions lies somewhere between Sitka and Puget Sound. No *Embiotocidae* are found at Sitka.

The relative number of species at the principal localities is as follows:

The whole of Alaska	109 species
Puget Sound	106 "
San Francisco	155 "
Monterey	149 "
Santa Barbara	119 "
San Pedro	82 "
San Diego, including Cortes Banks	168 "

There are known from the entire region 382 species, belonging to 228

genera. Of these 116 genera, or more than half, are also found in the Atlantic ocean, and thirty-two species are found both in the Atlantic and in the Pacific. The genera having species in both oceans practically all belong to one of three classes: First, Tropical genera; second, Arctic genera, whose species are distributed throughout the Arctic seas; third, Pelagic and other genera having a wide distribution.

Among the remarkable additions made to the fauna of California during recent years are the following:

Bronchiostoma elongatum, which had been recorded but once, we have found in large quantities at San Diego.

Rhinoptera encenadae, based on a fragment of a jaw found at Encenada.

Perkinsia, a new genus of herrings.

Six species of *Scopelidae*.

The albacore *Euthynnus pelamys*, whose nearest recorded habitat had been Japan, was found at San Diego.

ON INDIANA SHREWS. By AMOS W. BUTLER.

Among the smaller mammals is a group of small forms generally known as shrews or mole mice. These are insect eating forms. They are little mouse-like bodies. The snout is quite elongated, extending beyond the incisors some distance. It is naked, and on its sides are to be found the nostrils. Although these small mammals are very abundant they are not often seen. They are doubtless most active at night but are not strictly nocturnal, for examples are sometimes to be found moving about in the bright sunlight. They feed upon such animal food as comes in their way, chiefly grubs, larvæ, slugs, terrestrial insects. They are very pugnacious, following mice into their nests and often attacking them. They also attack and kill each other, eating the carcass. They eat almost any kind of animal food, but of vegetation eat little. They are said to be fond of beechnuts, and will, when starved to it, eat corn, oats, wheat and other grains.

In confinement they have been known to attack and kill mice much larger than themselves. Their eyes are small, and while not covered, they can see but imperfectly. Their burrows may be found everywhere beneath meadow, pasture and lawn, under the accumulated vegetable mould of the forest, or the collection of decaying weeds of the thicket. Anywhere and

everywhere their small tunnels may be found. In no respect, that I know, are they injurious, but in all laborers in their little spheres for good. It has been thought, from the number of dead shrews that are sometimes found, that these little mammals are subject to epidemics.

They are naked and blind at birth. None hibernate, but all move about in the coldest weather. Shrews seem to be rejected as food by other animals, on account of an unpleasant odor they emit. Often have I known a cat to catch one and carry it about for some time, apparently loth to give it up, but never eating it and, in the end, rejecting it. Many superstitions are prevalent in Europe, particularly in Great Britain, regarding these little creatures but, so far as I know, none of them are notable in the folk-lore of our land.

The most abundant shrew in our state, and perhaps the most widely distributed in the United States, is the short-tailed shrew, *Blarina brevicauda*, (Say). An interesting account of a nest of this species is given by my friend, Mr. Charles Dury, of Avondale, Cincinnati, Ohio, in a letter of Dec. 28, 1891. The notes have since been published, (Journal Cincinnati Soc. Nat. Hist., 1892, p. 183), and I give them here:

"It is well known to entomologists that some very curious and interesting insects live in the nests of mice and other small mammals. December 13, 1891, I went out to hunt nests of 'field mice,' in hopes of finding a wonderful little beetle, called *Leptimus testaceus*, said to live in such nests. This species was an especial desideratum to me, as I had never succeeded in finding it. I went to an old orchard, and under the first log rolled over I discovered a nest and secured a mouse as she rushed out. She proved to be the 'Short-tailed Meadow Shrew,' *Blarina brevicauda*, (Say). The nest was made of small bits of leaves of the sycamore tree, lined with grass fibers, and situated in a hole or pocket excavated in the ground. I lifted the nest into the sifting net and sifted it over a sheet of white paper, and was overwhelmed at the result. The fine debris was a jumping, crawling mass of insect life, beetles, fleas, ticks and larvæ. I gathered and bottled 106 *Leptimus*, and many ran over the edge of the paper and escaped. There were over a hundred large, vicious looking fleas, most energetic biters (as I discovered from those that secured a lodgment in my clothing). How the mouse could live in such a den is a mystery. The other beetles associated with *Leptimus* were *Staphylinida*, or 'Rove Beetles' of species new to me, and so far I have been unable to identify them. *Leptimus* is a small, flat beetle, of a pale testaceous color, one-eighth inch long, without any trace of eyes."

A smaller shrew, which seems to be comparatively common in Vigo county and is found in the Whitewater valley, is *Blarina exilipes*, (Baird.) This shrew is locally known in Vigo county as the "Bee Shrew," from its habit of entering the hives and destroying the young brood.

A form from Hanover, Jefferson county, which is about the size of the last mentioned, was identified by Prof. S. F. Baird as the Cinereus Shrew, *Blarina cinerea*, (Bach.).

From Franklin county several very small shrews were sent to Dr. Elliott Coues. He pronounced them the "Least Shrew," *Blarina parva*, (Say). The species had remained unknown from the time of Say's description. This is, perhaps, the smallest mammal in the United States, and seems to be rather common in the Whitewater valley.

A specimen from North Manchester, Wabash county, taken by Mr. A. B. Ulrey, proves to be the Common Shrew, *Blarina platyrhinus*, (DeK), which has not before been found in the state. A revision of our shrews will probably soon be undertaken, and it is very much needed for they are now in a very tangled condition. Further investigation will doubtless add other forms to our fauna.

There are three species described by Duvernoy in 1842, from this state, that are not now known. They are:

Brachysorex harlani, (Duver.), New Harmony, Ind.

Brachysorex brevicaudatus, (Duver.), New Harmony, Ind.

Amphisorex lescurei, (Duver.), Wabash valley, Ind.

I should like to request all who have specimens of shrews and other small mammals to inform me of that fact, and to urge upon all our members the importance of obtaining and preserving all such animals they can. Especially is such material desirable from all parts of the Wabash valley. The specimens may easily be dropped into small bottles or jars of alcohol after being tagged and marked, in lead pencil, with date and locality of capture. A little co-operation on the part of the members of our academy, a little thoughtfulness in saving what is thrown in our way, will do much to clear up many of the murky places in our nomenclature, many of the fogs along the lines of geographical distribution.

NOTES ON INDIANA BIRDS. By AMOS W. BUTLER.

Since the publication of my recent paper on Indiana birds* several valuable notes have been received, relating to the birds of the state. Besides these, a fuller notice of some of the brief notes given in the paper mentioned may be worthy of note. Not only is much additional information needed as to the occurrence of birds within the state, but also it is of great value to have continued observations on the range, breeding range and habits of birds. From the results of such work, carefully performed, we may map the range of birds by counties and even by townships, and, as a result, be enabled to solve many of the knotty and unravelled problems of geographical distribution. One of the labors which this academy may well carry on, and none can be more valuable, is a biological survey of the state, carefully and sincerely worked out.

Junco hyemalis shufeldti (Coale). Shufeldt's Junco. The specimen of this bird taken at Lafayette, and reported by Dr. Erastus Test, is the second one taken east of Illinois. A single specimen having been taken in Maryland near Washington. This is a form of the Rocky Mountain region which seems to extend its range southeastward.

Ammodramus henslowii (Aud.) Henslow's Sparrow. Mr. Ruthven Deane informs me that he spent a day in July, 1891, making the acquaintance of Henslow's Sparrows at English Lake, Ind. He reports seeing no less than twenty-five specimens and says: "two of us killed about ten. They have been there all summer." Within five days after receiving Mr. Deane's notes my friend, Mr. Charles Dury, of Avondale, Cincinnati, Ohio, informed me of a visit of two friends of his to English Lake in July and August. He said they found Henslow's Sparrows rather common and breeding, and took some specimens, including some young birds. An adult taken there was kindly presented to me by Mr. Ralph Kellogg, one of the collectors. Upon inquiry, I learned that these gentlemen and a friend visited the same locality noted by Mr. Deane, and, further, that they were acquainted and had collected in the same meadows.

Cistothorus stellaris (Licht). Short-billed Marsh Wren. I am under obligations to Mr. Deane, to whom I am indebted for many valuable notes, for some observations on the breeding of the Short-billed Marsh Wren in the state. He says an employe at their club house at English lake brought in a nest taken there two or three years ago. In Mr. G. Frean Morcom's col-

*The Birds of Indiana, with illustrations of many of the species, by Amos W. Butler. (Transactions Indiana Horticultural Society, 1890.)

lection is a set of five eggs of this species, taken at Davis Station, Ind., June 3d, 1887. Mr. C. E. Aiken informs me he found them in marshes bordering sloughs in Lake county, in 1871.

Protonotaria citrea (Bodd)—Prothonotary Warbler. I desire to express my appreciation of the work of Mr. Herbert W. McBride in exploring the counties of Elkhart, Lagrange and Steuben, in Indiana, and St. Joseph county, Michigan, thereby adding materially to our knowledge of the range of the birds in that region, and especially in extending the known range of the Prothonotary Warbler into all of these counties. It was found commonly in all but Steuben. This, with Mrs. Jane L. Hine's discovery of the species in DeKalb county, is very interesting to students of bird distribution.

For the following notes I am indebted to Mr. C. E. Aiken, of Salt Lake City, Utah, well known for his zoological investigations in Colorado. He formerly lived in Chicago and collected in northwestern Indiana, in 1866-7-9 and 71, and occasionally in later years:

Ardea egretta (Gmel)—American Egret. Mr. Aiken informs me it breeds on the Kankakee river, near Water Valley, Ind.

Charadrius squatarola (L.)—Black-bellied Plover. One was killed by Mr. Aiken, in Lake county, in 1871.

Contopus borealis (Swains)—Olive-sided Flycatcher. Not rare in Lake county where I obtained a number of specimens in 1871. (Aiken.)

Xanthocephalus xanthocephalus (Bonap)—Yellow-headed Blackbird. Found abundantly along the Calumet river, in Lake county, in 1871. (Aiken.)

Coccothraustes vespertina (Coop)—Evening Grosbeak. A large number of specimens were obtained near Whiting Station, Ind., in 1886-7, by Mr. R. A. Turtle, of Chicago. (Aiken.)

Loxia curvirostra minor (Brehm)—American Crossbill. One of the most interesting of Mr. Aiken's notes is one of the occurrence of the crossbills in the extreme heat of summer, in the vicinity of Chicago and northwest Indiana. Of the American Crossbill he says: "In July and August, 1869, this bird became very abundant in the door yards in Chicago, and remained until late in the fall. They fed greedily upon seeds extracted from sunflowers and were so sluggish that one could approach within a few feet of them, so that they fell an easy prey to boys with catapults. In the latter part of August, of the same year, I found them common in flocks about farm yards in Lake county, Indiana.

Loxia leucoptera (Gmel)—White-winged Crossbill. Accompanied the pre-

ceding species, in 1869, and remained through the winter. Noticed in Lake county preceding. (Aiken.)

Ammodramus leconteii (Aud)—Leconte's Sparrow. I am pleased to be able to note, upon the authority of Mr. Aiken, the occurrence of this bird in northwest Indiana. About April 15th, 1887, he observed two birds which he thought were this species at Water Valley. About the same time in 1889, near the same place, he saw three of what appeared to be the same birds. Two of them were shot and proved to be this species.

Geothlypis formosa (Wils)—Kentucky Warbler. Mr. Aiken is able to extend the range of this species as far as Gibson Station, Ind., where, he says, several specimens were taken in May, 1887.

In addition might be added that the extreme dryness of the fall for the past two years has had a noticeable effect in lessening the number of marsh birds and water fowl throughout the part of the state where shooting such game is extensively indulged in. Rail, snipe and duck shooting has been worthless the past two autumns. Birds were few, for their favorite haunts were unsuited to their wants. Marshes and sloughs were dry, as were the creeks. Much of the lakes had disappeared, leaving instead "mud flats." Many species, ordinarily common, were rare and others altogether wanting. The open winters two years past and so far this winter, have encouraged many species which ordinarily pass the winter further south to remain with us, and other species which stay in winter in limited numbers have remained in quantities.

SOME NOTES ON THE BIRDS OF INDIANA. By R. WES McBRIDE.

Loon, *Urinator imber*, Gunn. Mr. A. W. Butler, in his admirable and excellent catalogue of the birds of Indiana, says of the Loon, or Great Northern Diver: "I have no knowledge of their breeding within the state, although they will probably be found to do so." I can personally testify that it is a summer resident of Steuben county, and that it breeds in at least two of the many beautiful lakes of that county. Their eggs have been taken at Lake James and Crooked Lake. I have been familiar with those lakes for more than twenty years, and have never failed to find them there in summer. I have also seen them in the breeding season in Hamilton Lake and Golden Lake, also in Steuben county; in Turkey Lake, on the

line between Steuben and Lagrange counties, and in Bear Lake, Noble county.

Yellow-bellied Wood-pecker, *Sphyrapicus varius*, L. Is said, in the catalogue, to have bred rarely, if at all, in DeKalb county since 1888. Herbert W. McBride found a nest with three eggs near Waterloo, May 13, 1889.

Bobolink, *Dolichonyx oryzivorus* L. Ten years ago this bird was very rare in DeKalb and Steuben counties. Now it is a common summer resident and breeds in both counties. It is, however, still very rare in Elkhart county, only a short distance west, with the apparent conditions not materially different.

Brown Creeper, *Certhia familiaris americana*, Bp. Of this bird Mr. Butler says: "I have never known it to breed in the state, but Mr. H. W. McBride thinks it breeds in DeKalb county." I can say positively that I know it breeds in Steuben county. In my note-book I find the following under date of May 8th, 1882: "Brown Creeper; taken near Golden Lake, Steuben county, Indiana. Nest in crevice, where the bark had started from a dead tree, about four feet from the ground, in a swampy tract in "Crane town." Nest composed of sticks, bark and feathers. Six eggs, beauties. Incubation commenced. Embryos about half developed." I have a very distinct recollection of the matter. The "Crane town" referred to in the note is a heronry which we were exploring. The water was high and we were in a boat. I placed my hand against a tree to push the boat past it, when the bird flew off the nest, which was within a few inches of my hand. The bird remained near me until after I had secured the eggs and examined the nest. The appearance and characteristics of the Brown Creeper are so marked that it could hardly be mistaken for any other bird. I could not possibly be mistaken in its identification. In addition to this, the location and construction of the nest and the eggs themselves are all typical and characteristic.

Another nest and set of eggs were taken in May, 1883, at Fox Lake, near Angola, by my sons, Charles H. and Herbert W. The identification in this case was as satisfactory and unmistakable as in the other. Since that time, while I have frequently seen them during the breeding season, both in Steuben and DeKalb counties, I have found no other nests.

Tufted Titmouse, *Parus bicolor*, L. Is noted in the catalogue as an occasional straggler in northern Indiana. It breeds in Elkhart county. June 12th, 1891, Herbert W. McBride found a nest near Elkhart containing seven young birds.

THE SCALES OF LEPIDOPTERA. By M. B. THOMAS.

THE JEGERIA OF CENTRAL OHIO. By D. S. KELLCOTT.

SOME INSECTS OF TASMANIA. By F. M. WEBSTER.

[ABSTRACT.]

Although occupying a position in the southern hemisphere similar as to latitude to the northern half of Indiana and southern Michigan, the insect fauna more nearly resembles that of southern Texas, being strikingly semi-tropical. In the vicinity of Hobart, during the last of January, a season corresponding to our August, Phytophagus coleoptera, especially of the Chrysomelidæ and Rhynchophora, were very abundant, while carnivorous species, though strikingly poorly represented, included several Coccinellidæ and one Lepidopterous species—a rare object in any country. A noticeable feature, but one peculiar to island insects, was the lack of flying species along the coast.

A single butterfly, swift and strong of wing, was the only capture made in Lepidoptera. Another feature of island insects was noticed in the preponderance of species of a bronzy or yellowish color. The young eucalyptus trees afford a rich field for collectors during the summer season.

EARLY PUBLISHED REFERENCES TO INJURIOUS INSECTS. By F. M. Webster.

THE CONTINUITY OF THE GERM PLASM IN VERTEBRATES. By CARL H. EIGENMANN. Published in part in the Journal of Morphology, pp. 481–492, plate XXXI, 1892, under the title “On the precocious segregation of the sex-cells in *Micrometrus aggreatus* Gibbons.”

The theory of the continuity of the germ plasm as finally formulated by Weismann assumes that “there is not only a continuity between the ovum which gives rise to parent and the ovum which gives rise to the offspring” but in the successive generations between the ovum which pro-

duces the parent and the ovum which produces the offspring the character of the original ovum is never lost by differentiation. There is then a continuous chain of reproductive cells quite apart from the body cells or more frequently a series of body cells through which the unchanged germ plasm of the parent is transmitted to future generations. The germ cells are, therefore, not the product of the adult body but the direct offspring from the germ cell of the preceding generations.

The observations bearing out much of this theory have been mostly confined to invertebrates. All of our works on the comparative anatomy of vertebrates, as well as our works on embryology, tell us that the sexual organs in vertebrates arise from the germinal epithelium which is not differentiated until the embryo is completely formed. The most lucid descriptions of the early stages were given by Balfour for Elasmobranchs ten years ago, and the latest observations published by Jungersen in 1889 have not given anything concerning the stages less than two millimeters long.

While preparing the sections for the ontogeny of *Cymatogaster aggregatus*, one of the viviparous Embiotocidae, I frequently observed large, indifferent cells in the mesoblast. I at first supposed them to be cells in a pathological condition. When, however, all the eggs from one ovary were observed to contain such cells, I re-examined every embryo, and soon found that the cells are not pathological, but are a normal structure present in all embryos of a certain age. Further study showed them to be sex-cells of the future germinal epithelium. Our knowledge of the early stages of the sex-cells of vertebrates does not extend back beyond the condition described by Balfour and Jungersen. In the present study I have been able to trace them back to probably the fifth segmentation.

Our knowledge of the sex-cells in general has been summed up by Weismann as follows: "In certain insects the development of the egg into the embryo, that is, the segmentation of the egg, begins with the separation of a few small cells from the main body of the egg. These are the reproductive cells, and at a later period they are taken into the interior of the animal and form its reproductive organs. Again, in certain smaller fresh-water crustacea (Daphnidæ) the future reproductive cells become distinct at a very early period, although not quite at the beginning of segmentation, i. e., when the egg has divided into not more than thirty segments. Here also the cells which are separated early form the reproductive organs of the animal. The separation of the reproductive cells from those of the body takes place at a still later period, viz. at the close of segmentation, in Sag-

itta, a pelagic free-swimming form. In vertebrata they do not become distinct from the cells of the body until the embryo is completely formed." It will be seen that in some vertebrates (*Cymatogaster*) a similar segregation of "germ plasm" takes place quite early. In brief, the sex-cells of *Cymatogaster* first become normally conspicuous in the mesoblast where the germ layers are fused before any protovertebræ are formed. They can be seen in earlier stages, but they do not stand out so prominently from the other cells. In exceptional cases, the sex-cells can be traced back to probably the *fifth* segmentation.

The sex-cells can first be distinguished from the surrounding cells about the time the blastopore closes. The earliest ones distinguishable, exclusive of abnormal cases, are from an ovary in the eggs of which the blastopore is not yet closed, or is just closed and in which the mesoderm is not yet split off from the entoderm. Only two cells which can with certainty be said to be sex-cells are seen in one of these eggs. They differ from the surrounding cells in having well-defined, rounded outlines, and in the distribution of the chromatin in the nucleus. The chromatin of the surrounding cells is collected in one, or, if the cells are undergoing division, in two or three masses. The chromatin of the sex-cells is uniformly distributed in small granules.

In the eggs of another ovary, in which thickenings are formed for some distance, and the mesoblast is separated from the entoderm by a well-marked line, the sex-cells stand out from the surrounding cells with great prominence. This is not due to any marked change in the sex-cells themselves, but rather to the fact that the surrounding cells have undergone further division and are crowded so that the boundaries are not defined, while those of the rounded sex-cells are well marked.

The largest and most conspicuous cell of this stage lies in the mesoblast just beside the chorda. It measures $18 \times 23 \text{ } \mu$, and has a nucleus measuring about $6 \text{ } \mu$. On comparing this with segmenting eggs, it is found that it agrees in size with some of the cells of an egg undergoing the ninth segmentation and in all probability it is a cell remaining unchanged from that stage. It contains yolk particles. Most of the sex-cells are collected in a limited region at this stage in the thickened portion of the embryo, where the three germ layers fuse. This would lend force to the supposition that they are derived from two cells at most—one dextral and one sinistral. There are a few scattered cells in other parts of the embryo which cannot be so derived unless they early migrate from their original position.

There are, on an average, thirteen sex-cells in an egg of this stage. The largest number noticed is seventeen, the smallest nine.

In a larva just hatched, the longest diameter of which, measuring in a straight line, is 0.45 mm., there are ten sex-cells. In this embryo about nine protovertebræ have been formed. Most of the sex-cells are large, the largest having a diameter of 23 *m*, with a nucleus of 8 *m*. The smallest cell measures but 11 *m* in diameter. The distribution of these cells has become markedly changed from the conditions obtaining in the two-protovertebræ stage. Two of the cells, in the embryos examined, are found in the cephalic region, one on either side a short distance posterior to the origin of the chorda. The remainder are distributed as follows: one below the seventh sinistral protovertebra; three in the left side of the tail, i. e. in the region in which protovertebrae have not yet appeared; and three in the right side of the tail.

The cells in this stage stain deeper and much more uniformly than the surrounding cells with Grenacher's hæmatoxylin. They greatly resemble the very early conditions of these cells, and the number would seem to indicate that there has been no segmentation since the two-protovertebræ stage. In other larvæ of the same stage there are ten, eight, five, and nine cells, respectively.

In larvæ 2.5 mm. long there are fourteen to sixteen cells and the number cannot have been increased much since their earliest condition, even if we assume that two or more have been lodged in the gill region, and two in the anterior part of the body. The majority of the cells in this larva are confined to a region only 0.20 mm. long; and if we consider the doubtful cells in the anterior region, the total length over which these cells are distributed is about 0.50 mm. from the anus forward. The sex-cells in this stage measure 9-13 *m*. Balfour's admirable account of these "primitive ova" (*Elasmobranch Fishes*, pp. 130-136) might almost be used bodily to describe the same structures in *Cymatogaster* and *Abrona* 2.5 mm. long. He observed that the younger ones contain many yolk spherules, and suggests that the cells themselves may have migrated to their position from a peripheral portion of the blastoderm, since "they are the only mesoblast cells filled at this period with yolk spherules." He was at a loss as to how they arose, and thought he could detect cells intermediate in size between them and the neighboring cells. As has been seen, the yolk particles simply remain unchanged from the original condition when the sex-cells are segregated.

Several figures would seem to indicate that one of the larger cells of an early stage divides and gives rise to the groups of smaller cells in a later stage. This can scarcely be the case, since the number of cells in the earlier and later stages are about equal, unless a number of the earlier cells atrophy or are resorbed. The loss of four cells, two in the gill region, and two in the region of the fifth body somite, is probable, but even with the addition of these, the number of cells in the last stage examined does not exceed the average number in early stages when the cells are quite large. The reduction in size can, therefore, be explained only by supposing that the individual cells are reduced in size during development. It would be interesting to consider here the causes that lead these sex-cells to again grow and divide. Since, however, this process does not begin in the stages under consideration, this matter must be left till later stages are examined.

BIOLOGICAL STATIONS. By CARL H. EIGENMANN.

The early naturalists noted briefly the animals and plants they saw at home or abroad. A few centuries later they added figures to their enumerations. Later still skins were preserved, and last of all the whole animals were preserved, gathered into large museums, where they soaked and rotted twenty-five years, perhaps, before some one came along to study them. Some of our ornithologists and conchologists, and even some ichthyologists have not yet passed beyond this skin stage in their development. Many others, on the other hand, have passed this last stage and have ceased to content themselves with the catalogueing of specimens and now study the method, whys and wherefores of the things about them.

This school was established when Johannes Müller first dipped a net for pelagic animals. When it was found that the hows, whys and wherefores could best be studied in the lowest creatures, naturalists flocked to the sea shore, at first during their vacations. As methods for study increased and apparatus multiplied permanent Marine Biological Stations were evolved. First of these were the Naples Zoological Station and Agassiz's School at Penikese, both established in 1873. The aims of the two were slightly different. The Naples station was for original investigation. The Penikese school it was hoped would awaken an interest in zoology in America. There are now a large number of stations along the European coast, some large and some small, but it is not the intention to speak of these.

Penikese died with Agassiz. I have lately been on a pilgrimage to the old buildings. The motto "eat, drink and be merry" still hangs in the old dining-hall. On the walls of the lecture-room are the mottoes placed there by Agassiz's pupils: "A laboratory is to me a sanctuary. I would have nothing done in it unworthy its great author." "Study to translate what actually exists. Be courageous enough to say 'I do not know,' " and "Study nature not books." The outlines of the last lecture delivered at Penikese eighteen years ago are still on the blackboard. At this window Dr. Whitman stuffed terns, at the other Dr. Brooks cracked clams and at another Dr. Jordan studied seaweeds.

Penikese had been donated and the buildings erected by a tobacco merchant, Anderson, of New York. It was found that the location was too inaccessible and the fauna of the island too poor so that the \$30,000 buildings were abandoned for less commodious but more favorably situated quarters. There are at present several marine laboratories on the coast of America, and several summer schools which are located on the seashore, and do a certain amount of marine biological work.

In 1881 a number of Boston women established a laboratory at Annisquam, Mass., where students and teachers could work during the summer. These ladies were afterwards instrumental in the foundation of the Marine Biological Association whose laboratory is at Woods Holl on Vineyard Sound.

Alexander Agassiz several years ago built the Newport Marine Laboratory, to which he has frequently invited students. Here the advanced students of Harvard University work during the summer. This laboratory is the best equipped of any in the United States, but it is practically private and has room for but eight students.

The United States Fish Commission, after spending several summers at various places on the Atlantic finally built a permanent station at Woods Holl. This is by far the largest station in America and it was Professor Baird's hope and intention to make it the equal of the famous station at Naples. But the elaborate laboratories, aquaria, docks, boats and large hotel did not attract the men it was hoped to collect.

Another laboratory has lately been established on Long Island, but of this nothing definite can be said yet. Still another has been established by the University of Pennsylvania.

This brings us back to the station of the Marine Biological Association which deserves a better notice.

It is by far the most important in its scope, aims, methods and future prospects. It is chiefly supported by the munificence of Boston people. The buildings consist at present of the laboratory and the newly acquired dwelling house. The north side of the upper floors is divided into small rooms 7x10 feet. Each of these is supplied with a table, an aquarium, sink, shelves and a full set of reagents and glassware. These rooms are occupied by investigators doing independent work and are offered free. The remaining portion of the second floor is occupied by the library, the director's rooms, reagent room and the laboratory of the advanced students. The lower floor by the lecture room and laboratory for students most of whom are teachers at one place or another.

This is the Mecca of the modern school of naturalists, and there are collected, at this place, teachers and students from all the leading institutions.

The laboratories for students are open during July and August. Investigators come earlier and stay later.

In enumerating what has been done on the east coast it is perhaps well to state what may be done on our west coast. Our eastern laboratories necessarily close during winter. On the Southern California coast where the thermometer never records the freezing point ice does not drive the investigator away in winter. The boundless wealth of the fauna and flora together with the favorable climate will doubtless sometime attract to this region a number at least the equal of that now collected at Woods Holl or Naples. At present the sole marine station on the whole coast is my little laboratory at San Diego which is a mile from the shore and the windows of which are now nailed up.

I have before [San Francisco Chronicle, November 30, 1890.] urged the establishment of marine laboratories on the west coast where they can equal the Naples station and it is to be hoped that one may soon be endowed not only for elementary work but for original research with a permanent corps of investigators.

P. S.—Since this was written Timothy Hopkins has endowed a marine laboratory to be established at Monterey, and Adolph Sutro will maintain another at the entrance of San Francisco Bay. Who will utilize the best locality—San Diego?

THE EYES OF BLIND FISH. BY CARL H. EIGENMANN. Published in Proc. U. S. Nat. Mus. for 1892, with plates.

[ABSTRACT.]

Whenever the conditions are favorable blind fishes are developed. These are always related to species inhabiting neighboring open waters. Blind fishes are found in caves, in the deep sea, and at San Diego one lives beneath rocks. While such regions usually contain blind fishes not all the fishes inhabiting these regions are blind. Many species found in the deeper parts of the ocean have well developed eyes, while others living in shallower water are blind. The explanation for this fact probably lies in the length of time a given species has inhabited the present locality. In all blind fishes the eyes have undergone a process of degeneration. This is very strikingly seen in the development of the Point Loma blind fish, *Typhlogobius californiensis* Steindachner. The embryo, before it is hatched, has eyes as well developed as the embryo of any other fish. When the individuals have reached the length of an inch they can still see a short distance, but it is evident that the eye has stopped growing long before this age is reached. In the adult condition the eye has become degenerate and covered with a thick skin, and the fish is totally blind.

ON THE PRESENCE OF AN OPERCULUM IN THE ASPREDINIDÆ. By CARL H. EIGENMANN. Published in American Naturalist, January, 1892, p. 71, plate VI.

[ABSTRACT.]

In our "Revision of the South American Nematognathi," (p. 9) we defined the Bunocephalidæ—Aspredinidæ as having no opercle. In this we followed Cope, who separated the Aspredinidæ from the remaining Nematognathi by their lack of an opercle.

We have lately obtained a specimen of *Aspredo aspredo* Linnaeus from the Museum of Comparative Zoology, and have re-examined this point. The closer inspection has demonstrated the presence of a minute operculum attached to the upper posterior border of the expanded hyomandibular. It is movable in moist preparations but becomes immovably fixed with drying, which may have led to the original statement. The interopercle is about as large as the opercle, and apparently immovably joined to the hyomandibular and preopercle. (The skull of this species, with the suspensorium, was figured.)

A REVIEW OF THE EMBIOTOCIDÆ. BY A. B. ULREY. In press, Report of the U. S. fish commission.

[ABSTRACT.]

On examining specimens of this family and the literature bearing on the subject, I find the following species, with their localities:

1. *Hypsaurus caryi* Agassiz. Habitat: Coast of California from San Diego to San Francisco.
2. *Damalichthys argyrosomus* Girard. Habitat: Pacific coast from San Diego to Vancouver Island.
3. *Hyperprosopon analis* A. Agassiz. Habitat: Port Harford to San Francisco. Rare.
4. *Hyperprosopon argenteus* Gibbons. Habitat: Astoria to Encenada.
5. *Hyperprosopon agassizi* Gill. Habitat: Coast of California.
6. *Holconotus rhodoterus* Agassiz. Habitat: Coast of California from San Francisco to San Diego.
7. *Amphistichus argenteus* Agassiz. Habitat: San Diego to Cape Flattery.
8. *Rhacochilus toxotes* Agassiz. Habitat: San Francisco to San Pedro.
9. *Neoditrema ransonneti* Steindachner and Doderlein. Habitat: Japan.
10. *Ditrema temminckii* Bleeker. Habitat: Japan.
11. *Ditrema smittii* Nyström. Habitat: Japan.
12. *Embiotoca jacksoni* Agassiz. Habitat: San Diego to Puget Sound.
13. *Phanerodon lateralis* Agassiz. Habitat: Vancouver Island to San Diego. Rare southward.
14. *Phanerodon furcatus* Girard. Habitat: San Diego to San Francisco.
15. *Phanerodon atripes* Jordan and Gilbert. Habitat: Monterey to Cortes Banks.
16. *Brachyistius frenatus* Gill. Habitat: San Diego to Puget Sound.
17. *Brachyistius rosaceus* Jordan and Gilbert. Habitat: Off San Francisco in deep water.
18. *Cymatogaster aggregatus* Gibbons. Habitat: Pacific coast of the United States.
19. *Abeona minima* Gibbons. Habitat: San Diego to San Francisco.
20. *Abeona aurora* Jordan and Gilbert. Habitat: Monterey Bay.
21. *Hysterocarpus traski* Gibbons. Habitat: California (Sacramento river in fresh water).

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March 9, 1894

PROCEEDINGS

OF THE

Indiana Academy of Science.

1892.

BROOKVILLE, IND.

PROCEEDINGS

77384.

OF THE

Indiana Academy of Science,

1892.

O. P. HAY,
C. A. WALDO, } Editors.
J. M. COULTER, }

A. W. BUTLER,
C. H. EIGENMANN,
V. F. MARSTERS,
W. A. NOYES, } Assistant Editors.
I. M. UNDERWOOD,
F. M. WEBSTER, }

TERRE HAUTE, IND.
PRESS OF MOORE & LANGEN.
1893.

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J. P. D. JOHN,	T. C. MENDENHALL,	O. P. HAY,
D. S. JORDAN,	J. L. CAMPBELL,	J. C. BRANNER.

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Ichthyology	CARL H. EIGENMANN.
Ornithology	AMOS W. BUTLER.
Herpetology	O. P. HAY.
Entomology	F. M. WEBSTER.
Mammalogy	E. R. QUICK.

* Resigned.
† To fill vacancy.

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NOMINATIONS.

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AUDITING.

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PLAN FOR PUBLICATION.

STANLEY COULTER,

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STATE LIBRARY.

C. A. WALDO.

J. M. COULTER,

W. A. NOYES.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

J. C. ARTHUR,

J. M. COULTER,

W. H. EVANS.

EDITORS.

O. P. HAY,

C. A. WALDO,

J. M. COULTER.

PRESERVATION OF ABORIGINAL EARTHWORKS NEAR ANDERSON.

J. M. COULTER,

J. P. D. JOHN,

O. J. CRAIG,

D. W. DENNIS,

F. A. WALKER.

BIOLOGICAL SURVEY.

L. M. UNDERWOOD,

A. W. BUTLER,

J. M. COULTER.

DIRECTORS BIOLOGICAL SURVEY.

L. M. UNDERWOOD,

C. H. EIGENMANN,

V. F. MARSTERS.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. WALDO,

J. M. COULTER,

A. W. BUTLER.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	PRESIDENT.	SECRETARY.	ASST. SECRETARY.	TREASURER.
1885-6	David S. Jordan.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1886-7	John M. Coulter.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1887-8	J. P. D. John.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1888-9	John C. Branner.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1889-90	T. C. Mendenhall.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1890-1	O. P. Hay.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1891-2	J. L. Campbell.	Amos W. Butler.	. . . . .	C. A. Waldo.
1892-3	J. C. Arthur.	Amos W. Butler.	Stanley Coulter. W. W. Norman.	C. A. Waldo.

CONSTITUTION.

SECTION 1. This Association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

SEC. 3. Members of this Academy shall consist of three classes, active, non-resident and honorary. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter, an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the state. Honorary members may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case, a three fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on applications for membership, who shall consider such application and report to the Academy before the election.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, a vice president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices, and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting, appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 5. The annual meeting of this Academy shall be held in the city of Indianapolis, within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the

executive committee. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance a knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.

3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

6. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

HONORARY MEMBER.

Daniel Kirkwood Riverside, Cal.

NON-RESIDENT MEMBERS.

John C. Branner Palo Alto, Cal.
D. H. Campbell Palo Alto, Cal.
B. W. Evermann Washington, D. C.
Charles H. Gilbert Palo Alto, Cal.
C. W. Green Palo Alto, Cal.
C. W. Hargitt Syracuse, N. Y.
Edward Hughes Palo Alto, Cal.
O. P. Jenkins Palo Alto, Cal.
David S. Jordan Palo Alto, Cal.
J. S. Kingsley Tufts College, Mass.
Alfred Springer Cincinnati, Ohio.
Robert B. Warder Washington, D. C.

ACTIVE MEMBERS.

J. Alex. Adair Hanover.
J. C. Arthur Lafayette.
Harry F. Bain Iowa City, Iowa.
Philip S. Baker Greencastle.
Timothy H. Ball Crown Point.
George W. Benton Indianapolis.
Alexander Black Greencastle.
Willis S. Blatchley Terre Haute.
Henry L. Bolley Fargo, N. D.
M. A. Brannon Ft. Wayne.
W. V. Brown Greencastle.
H. L. Bruner Irvington.
J. B. Burris Cloverdale.
Amos W. Butler Brookville.
Noble C. Butler Indianapolis.
J. L. Campbell Crawfordsville.

J. T. Campbell	Rockville.
J. Fred Clearwaters	Greencastle.
John M. Coulter	Lake Forest, Ill..
Stanley Coulter	Lafayette.
U. O. Cox	Mankato, Minn.
M. E. Crowell	Indianapolis.
Will Cumback	Greensburg.
George L. Curtiss	Greencastle.
B. M. Davis	Irvington.
D. W. Dennis	Richmond.
Chas. R. Dryer	Terre Haute.
Joseph Eastman	Indianapolis.
H. T. Eddy	Terre Haute.
Carl H. Eigenmann	Bloomington.
E. S. Elder	Indianapolis.
Samuel G. Evans	Evansville.
E. M. Fisher	Lake Forest, Ill.
Wilbur A. Fisk	Richmond.
J. J. Flather	Lafayette.
Robert G. Gillum	Terre Haute.
U. F. Glick	Newbern.
Katherine E. Golden	Lafayette.
Michael Golden	Lafayette.
C. F. Goodwin	Brookville.
S. S. Gorby	Indianapolis.
W. F. M. Goss	Lafayette.
Vernon Gould	Rochester.
Thomas Gray	Terre Haute.
Edwin Stanton Hallett	Corydon.
A. S. Hathaway	Terre Haute.
O. P. Hay	Chicago, Ill.
Wm. Perry Hay	Irvington.
Franklin W. Hayes	Indianapolis.
Robert Hessler	Indianapolis.
W. A. Hester	Evansville.
T. H. Hibben	Indianapolis.
Geo. C. Hubbard	Moore's Hill.
J. W. Hubbard	Bloomington.

H. A. Huston	Lafayette.
Thomas M. Iden	Irvington.
Alex. Jameson	Indianapolis.
A. E. Jessup	Carmel.
J. P. D. John	Greencastle.
Sylvester Johnson	Irvington.
W. B. Johnson	Franklin.
J. G. Kingsbury	Irvington.
W. H. Kirchner.	Terre Haute.
Daniel Layman	Indianapolis.
W. S. Lemen	Indianapolis.
Robert E. Lyons	Bloomington.
Herbert W. McBride	Chicago, Ill.
Robert Wesley McBride	Indianapolis.
D. T. McDougal	Minneapolis, Minn.
F. M. McFarland	Palo Alto, Cal.
J. W. Marsee	Indianapolis.
Vernon F. Marsters	Bloomington.
C. Leo Mees	Terre Haute.
T. C. Mendenhall	Washington, D. C.
Joseph Moore	Richmond.
Warren K. Moorehead	Xenia, Ohio.
David M. Mottier	Bloomington.
J. P. Naylor	Greencastle.
Charles E. Newlin	Indianapolis.
W. W. Norman	Greencastle.
W. A. Noyes	Terre Haute.
J. H. Oliver	Indianapolis.
D. A. Owen	Franklin.
Wallace C. Palmer	Columbia City.
Alfred E. Phillips	Lafayette.
Elwood Pleas	Dunrieth.
E. R. Quick	Brookville.
Ryland Ratliff	Fairmount.
Thomas B. Redding	New Castle.
D. C. Ridgley	North Manchester.
Herman B. Ritter	Indianapolis.
George L. Roberts	Greensburg.

L. J. Rettger	Terre Haute.
John F. Schnaible	Lafayette.
J. T. Scovell	Terre Haute.
C. E. Schafer	Huntington.
W. P. Shannon	Greensburg.
G. W. Sloan	Indianapolis.
Alexander Smith	Crawfordsville.
W. J. Spillman	Monmouth, Ore.
Sidney T. Sterling	Camden.
M. C. Stevens	Lafayette.
Winthrop E. Stone	Lafayette.
A. E. Swann	Indianapolis.
Frank B. Taylor	Ft. Wayne.
Erastus Test	Lafayette.
F. C. Test	Washington, D. C.
Mason B. Thomas	Crawfordsville.
Wm. M. Thrasher	Irvington.
A. L. Treadwell	Oxford, Ohio.
Joseph H. Tudor	Baltimore, Md.
E. B. Uline	Lake Forest, Ill.
A. B. Ulrey	Bloomington.
L. M. Underwood	Greencastle.
T. C. Van Nuys	Bloomington.
C. A. Waldo	Greencastle.
F. A. Walker	Anderson.
F. M. Webster	Wooster, Ohio.
M. W. Wells	Indianapolis.
J. R. Wiest	Richmond.
H. W. Wiley	Washington, D. C.
William S. Wood	Seymour.
A. J. Woolman	Duluth, Minn.
A. Harvey Young	Hanover.
Honorary member	1
Non-resident members	12
Active members	121
	—
Total	134

SPRING MEETING.

The spring meeting of the Academy was held at Terre Haute, Ind., May 17, 18 and 19, 1893.

The meeting was called to order by Vice President Noyes, at 3 o'clock p. m., May 17, in the chemical lecture room of Rose Polytechnic Institute.

J. M. Coulter, W. W. Norman and J. T. Scovell were appointed Membership Committee.

L. M. Underwood presented a report from the committee on State Biological Survey, of which he is chairman. The chairman was instructed to appoint two other members to serve on the committee with him and to present plans at this meeting for carrying on the work.

Acting president Noyes announced an excursion for the next day, leaving the Terre Haute House early in the morning, crossing the river, thence to Durkee's Ferry, returning to Terre Haute in time for supper.

In the evening the Academy met in the Normal school. President Arthur presided.

Dr. T. C. Mendenhall spoke of "The Summit of the Continent." Dr. J. M. Coulter spoke on "Forestry."

Later in the evening another meeting was held at the Terre Haute House. Prof. Underwood announced he had requested to serve with him on the committee on Biological Survey, J. M. Coulter and A. W. Butler.

The members then discussed the question of the relation the Academy should sustain to the State.

C. A. Waldo, J. M. Coulter and A. W. Butler were appointed a committee to consider this.

The resignation of Prof. Stanley Coulter, as assistant secretary, was accepted.

A meeting of the Academy was held on the evening of May 18th, at the same place.

The committee on Biological Survey announced that for the present

three directors, one representing Botany, one Zoology and one Paleontology be appointed. The recommendation was approved. L. M. Underwood, C. H. Eigenmann and V. F. Marsters were appointed such committee.

Instructions were given the Programme Committee regarding arrangements for the winter meeting.

W. W. Norman was elected assistant secretary.

The day was spent along the west side of the Wabash river, above Terre Haute, and was greatly enjoyed. Some of the members continued their investigations the following day.

WINTER MEETING.
INDIANAPOLIS, DEC. 28, 29, 1892.

PRESIDENT'S ADDRESS.

THE INTERDEPENDENCE OF LIBERAL PURSUITS.

J. L. CAMPBELL, CRAWFORDSVILLE.

The crowning group in stone for the new library building in Indianapolis, by Richard W. Bock, of Chicago, is composed of three figures, representing Literature, Science and Art.

The central figure, sixteen feet in height, represents Science, holding in his right hand stretched upward the torch of enlightenment, and in his left a palm, the reward of victory.

In a sitting posture to the right a female figure represents Literature. She holds a book in the left hand resting on the knee, and with uplifted pen in the right hand she is presented at the inspired moment—write.

The third figure, representing Art, is also a woman. She holds a drawing board upon which she is about to produce a design.

This group suggests the topic for discussion, and the subject may be entitled the Interdependence of the Liberal Pursuits, or in the spirit of the times, the need of an intellectual trust, whereby the interests of science, literature and art may be better cared for, and under its fostering care there may be developed higher art, purer literature and nobler science.

The group in stone is a unit, and my plea will be for the unity of these liberal pursuits.

The distinguishing characteristic of our day is devotion to specialties, and this devotion has made us strangers to each other.

A critical examination of the productions in the various departments of literature and science will disclose many defects, which may be traced chiefly to the want of interchange of thought.

The scientific treatises often are defective in style and expression, and the literary works frequently are laughably absurd in their scientific by-plays.

The scientific man waves aside with contempt the latest novel, and the novelist returns the compliment by pitying the devotion of the discoverer of an unclassified bug or a fresh compound.

A more generous fellowship is needed for mutual benefit.

This criticism is not intended to be censorious nor unjust; neither is it directed against earnest work in specialties. There can be no valuable results except by loving and exclusive efforts along chosen lines.

It is not asked that the chemist by his compounds should seek for poetry in his crucible; nor that the biologist with his dissecting tools create the life which his search destroys, much less reproduce the higher life of thought, of passion, and of hope, which breathe in the works of the dramatist and in the pages of the writer of fiction.

But outside of our laboratories of books and blowpipes, in our hours of ease, if you please, may not profitable relaxation be found in a better acquaintance with our neighbors.

The poet takes his walks alone that his communion with nature may not be disturbed, but it is possible that he might find valuable assistance in his translation of the "books in brooks" in the "drawing rooms" of the hydraulic engineer.

The geologist no less than the poet may find "sermons in stones," and each may be benefited by contact with the other.

Is it not possible to secure better results by the union of science and literature than are now gotten by their separation and their too narrow circle of fellowship?

Listen to this wail from the Editor's Study in Harper's Magazine for September, 1892, and tell us what does it portend?

"Books are being replaced by newspapers and periodicals. A book shop used to be an intelligent center where readers met not only to keep the run of the thought of the world, but to exchange ideas about it. Few are so now. Book stalls have become shops of notions, of stationery, of newspapers, of artists' materials, of various bric a brac, with an only occasional real book that has attained exceptional notoriety.

"It is no longer profitable to keep a stock of general literature, and many of the brightest and best trained minds now are giving their entire time and energy to the daily and weekly press.

"In its swelling bulk the daily newspaper has become a magazine, and the magazine in a generation that must run as it reads takes the place of the book."

From the scientific side of book making also comes remarkable confessions of weakness. From the testimony of the writers themselves the books of yesterday already have been consigned to the top shelf, where indeed moth and dust do corrupt, but where thieves do not break through

to steal, while the books of to-day will be in the waste basket to-morrow. True, the language used is somewhat different from the above, but the meaning is essentially the same.

The claim is that so rapid are the advances in science that the text book of yesterday is antiquated, or in their illiterate lingo, "not up to the times," and so the butterfly products sport only their brief day and die.

Is it a necessity that books shall have this ephemeral existence? Is this a love that must so soon grow cold; a youth that without years must be old; a life that almost begins with death?

"I paint for immortality" was the inspired utterance of the greatest of artists, and is there to be no second Shakespeare whose writings will be immortal? Is there not an unentered field of research where we may discover the hidden qualities of the few books which endure?

With the confession of weakness and partial failure comes the question of possible increase of strength and more complete success. If there is a balm in Gilead let us seek for it, and if there is a physician anywhere who can cure let us search for him.

And for this purpose let us call a congress of all parties interested for mutual counsel, and, if found practicable, for mutual aid.

If the weakness is real in all departments of thought, and is discovered in all varieties of thought products, let the invitation to this congress of thinkers be general; let the workmen come from every separate shop to the great council chamber; the representatives of art, literature and science of every kind to the symposium of mind.

In this assembly let the historian and the physicist sit together; the biologist and the biographer; the poet and the chemist; the botanist and the linguist. Let the mathematician take counsel with the song writer, and the astronomer and the wanderer in the shoreless realms of fiction discuss the things common to both.

Then the new companionship would beget new inspiration; a better fellowship would lead to a broader culture; "know thyself" would yield to the more generous "know each other," and a fuller answer would be given to the greatest question, "how can men best fulfill their allotted destiny?"

With this liberal view of intellectual fellowship necessarily would come more liberal methods in the preparatory as well as in the wage earning period of life.

It is not the purpose of this lecture to enter upon the much discussed and never to be settled questions relating to the studies to be selected and

the methods to be pursued in the undergraduate part of preparatory training.

Without dispute broad general culture is the point and the essential requirement.

The deep foundations must be of stone, whatever is to be the superstructure.

My earnest plea is for more room in the elementary period for training in the branches which are extra, or rather pre-professional, and which must be mastered before any one can lay claim to a *liberal* education.

* * * * * *

If we were permitted to interpret Shakespeare's seven stages of life, his third would conclude with the undergraduate course, while the fourth, who enters as the "lover sighing like furnace with a woful ballad made to his mistress' eyebrow," would mean that devotion to professional study which is more than that of the lover and an attention more exacting than that of the most jealous mistress.

In the preparation for professional life no exclusiveness can be too exclusive, no labor or painstaking within the severest limits can be too exacting.

All that the most ardent advocate for specialties is accepted, and if presented to our great congress of thinkers would be unanimously adopted.

This is the time in life when the student should be lost to the world, when the claims of social life may be ignored, when culture even may be suspended in the eager search for facts.

If the chosen profession be science, the laboratory should be alike shop and parlor; if literature, to quote again from the Editor's Study, books only, "those unfailing faithful companions which stand mute and waiting on the shelves, in whose hearts are preserved the thought, the aspiration, the despair, the love, the heroism, the emotion, the tragedy, the immortal beauty, the bewitching loveliness of the ages."

So oblivious to outer things should be the professional student, that a casual glance at the daily newspaper could scarcely be allowed to keep him informed whether or not he himself has not died.

The usual commencement benediction welcomes the graduate to the great world of letters, but this welcome should be to the retirement and not to the activities of this realm of thought, and the interpretation should be that he has studied to be somebody, now let him learn to do something. A Paul even found it necessary to retire three years into Arabia

for this preparation for the work of directing religious thought for all after ages.

The generous, or rather general qualities of mind and heart, which necessarily have been but little called into activity during the years of professional study, are likely never to be revived, and so the years of active professional life usually are passed within the narrow limits of single professions. Lawyers prefer lawyers, and chemists, chemists. Doctors care only to talk with doctors, and preachers prefer to confine their attentions to the cloth. In the literary professions there is even more exclusiveness, for nothing is so dull and unattractive to writers of this class as the fields of science. Dynamite is greatly preferred by them for the intruder who would try to discuss a dynamo.

The cure for all this is better fellowship.

The Academy of Science purposes at the present session to cultivate this liberalizing of different pursuits within the range of the general purpose of the association. Instead of carrying out our programme by sections as heretofore, our desire is that the members may become interested in the work of others than those in the same specialty. The biologist must listen to the physicist, the chemist to the geologist, the archaeologist to the botanist, each for the time being esteeming the work of another better than his own. Thus within the limits of the sciences we are trying the interchange of thought for the better developing of thinking.

If this experiment proves successful may we not hope for a wider association of thinkers in some new organization, which will include all liberal pursuits?

* * * * *

The pleasant duty remains to me to extend fraternal greetings to the members of the Indiana Academy of Science.

This Academy is yet young in years, but the success already attained and the recognition secured among associations of kindred character are most gratifying to those of us who have been active members from the beginning. The new names added to our list year by year give cheering assurance of a prosperous future.

We meet this year in the closing days of an epoch of four hundred years of the world's history, dating from the birth of a hemisphere, and from this holiday ending of the old extend our happy new era greeting to the centuries to come.

Next year we will celebrate this fourth century date at the marble city

by the lake. The international exposition of 1893 will epitomize in material form the progress of the world for the centuries, and to no Mecca can the devotee of science turn with more reverent steps.

The interdependence of the liberal pursuits there will have practical illustrations of the most instructive character. The best thought of the centuries will be realized on canvass, in marble, in bronze, in exquisite fabrics, in jewels and ornaments of silver and gold, in the whirr of machinery and the flashes of electricity.

There may we study things, and there may we in profitable intercourse meet men. This will be the academy of science of the world.

PAPERS READ.

ON THE CONSTRUCTION OF A SENSITIVE GALVANOMETER. By BENJ. W. SNOW.

TESTS OF THE TORSIONAL STRENGTH OF A STEEL SHAFT. By THOS. GRAY.

ANALYTICAL AND QUATERNION TREATMENTS OF THE PROBLEM OF SUN AND PLANET.
By A. S. HATHAWAY.

INTRODUCTION.

The object of the paper is to show the greater simplicity of quaternions over analytics. For the purpose of comparison, the most condensed analytical treatment possible is adopted. This turns out to be precisely analagous to the quaternion treatment. Three equations, such as $m a = a'$, $m b = b'$, $m c = c'$ are written $m (a, b, c) = (a', b', c')$. By multiplying these equations by (x, y, z) is understood the result of multiplying the first by x , the second by y , the third by z , and adding, giving $m (a x + b y + c z) = (a' x + b' y + c' z)$. This corresponds to scalar multiplication in quaternions. By forming corresponding determinants with

x, y, z , is understood the set of equations $m \begin{vmatrix} a & b & c \\ x & y & z \end{vmatrix} = \begin{vmatrix} a' & b' & c' \\ x & y & z \end{vmatrix}$ or, in full $m(bz - cy, cx - az, ay - bx) = (b'z - c'y, c'x - a'z, a'y - b'x)$. This corresponds to vector multiplication in quaternions.

The analytical methods thus perfected are, in fact, a sort of degraded and cumbersome quaternion notation in which (a, b, c) stand for $ai - bj + ck$, etc. It involves the necessity of thinking by steps parallel to the axes, and when results are obtained it involves the fitting together of the various steps in order to see what is the actual state of affairs in space. To do this requires considerable practice and grasp of technique, all of which is avoided in quaternions. For example, equations (8) were unnecessary in quaternions, the results desired being sufficiently evident from (7); while even after (8) is derived the technique of equations of the first degree must be at command before the results stated can be seen in the analytical method. The letters m_1, m_2 in (9) and on are not the masses of (1) . . . (5).

EQUATIONS OF MOTION.

$$\begin{aligned} (1) \quad m_1 \begin{pmatrix} \frac{d^2 x_1}{dt^2}, \frac{d^2 y_1}{dt^2}, \frac{d^2 z_1}{dt^2} \end{pmatrix} &= \frac{m_1 m_2}{r^3} (x, y, z) & \left| \quad m_1 \frac{d^2 \dot{\rho}_1}{dt^2} = - \frac{m_1 m_2}{T^3 \dot{\rho}_1^2} \dot{\rho}_1 \right. \\ (2) \quad m_2 \begin{pmatrix} \frac{d^2 x_2}{dt^2}, \frac{d^2 y_2}{dt^2}, \frac{d^2 z_2}{dt^2} \end{pmatrix} &= - \frac{m_1 m_2}{r^3} (x, y, z) & \left| \quad m_2 \frac{d^2 \dot{\rho}_2}{dt^2} = - \frac{m_1 m_2}{T^3 \dot{\rho}_1^2} \dot{\rho}_1 \right. \\ \text{where } (x, y, z) &= (x_2 - x_1, y_2 - y_1, z_2 - z_1). & \left| \quad \text{where } \dot{\rho}_2 = -\dot{\rho}_2 - \dot{\rho}_1 \right. \\ \text{and } r &= (x^2 + y^2 + z^2)^{\frac{1}{2}} \end{aligned}$$

Adding (1), (2), also dividing out common m 's and subtracting, putting $M = m_1 + m_2$, we have:

$$\begin{aligned} (3) \quad (m_1 \frac{d^2 x_1}{dt^2} + m_2 \frac{d^2 x_2}{dt^2}, \dots, \dots) &= (0, 0, 0) & \left| \quad m_1 \frac{d^2 \dot{\rho}_1}{dt^2} + m_2 \frac{d^2 \dot{\rho}_2}{dt^2} = 0 \right. \\ (4) \quad \begin{pmatrix} \frac{d^2 x}{dt^2}, \frac{d^2 y}{dt^2}, \frac{d^2 z}{dt^2} \end{pmatrix} &= - \frac{M}{r^3} (x, y, z) & \left| \quad \frac{d^2 \dot{\rho}}{dt^2} = - \frac{M}{T^3 \dot{\rho}^2} \dot{\rho} \right. \end{aligned}$$

EQUATIONS OF MOTION INTEGRATED.

Integrating (3) twice, we have:

$$(5) \quad (m_1 x_1 + m_2 x_2, \dots, \dots) = \begin{pmatrix} m_1 \dot{\rho}_1 + m_2 \dot{\rho}_2 = a t + \beta. \\ (a t + b, a' t + b', a'' t + b'') \end{pmatrix}$$

Hence, the center of gravity moves in a straight line with uniform speed, viz:

In the direction $a:a':a''$ with speed: $\frac{1}{r} (a^2 + a'^2 + a''^2) : (m_1 + m_2)$.

Form corresponding products of (4) and $\left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt} \right)$ add and integrate,

$$(6) \frac{1}{2} \left[\left(\frac{dx}{dt} \right)^2 + \left(\frac{dy}{dt} \right)^2 + \left(\frac{dz}{dt} \right)^2 \right] = \frac{M}{r} - \frac{M}{2a}$$

In the direction a , with speed: $\frac{1}{r} a : M$.

Multiply (4) by $\frac{1}{r}$ and scalar-integrate:

$$\frac{1}{2} \frac{d}{dt} \left(\frac{r^2}{dt} \right) = \frac{M}{r} - \frac{M}{2a}$$

This is the equation of energy. It shows that the speed of a planet increases when its distance from the sun decreases, and *vice versa*. Also, since $M = m_1 + m_2$ is sensibly the same for all planets, therefore the speed of a planet depends only on its distance from the sun and a constant, $\frac{M}{2a}$, of its orbit (later shown to be its major axis).

Forming corresponding determinants of (4) with (x, y, z) and integrating:

$$(7) \begin{vmatrix} x & y & z \\ \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \end{vmatrix} = c (l, l_1, l_2)$$

where $l^2 = l_1^2 + l_2^2 = 1$ and c is positive.

Multiplying corresponding terms by (x, y, z) , and adding, we find:

$$(8) \begin{vmatrix} 1 & x & l_1 y & l_2 z \\ \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \end{vmatrix} = 0; \text{ similarly,} \\ \begin{vmatrix} 1 & \frac{dx}{dt} & l_1 \frac{dy}{dt} & l_2 \frac{dz}{dt} \end{vmatrix} = 0.$$

Multiplying (4) by $\frac{1}{r}$ and integrating the vector part:

$$\frac{1}{r} \frac{d}{dt} \left(\frac{r^2}{dt} \right) = c \lambda$$

where $\lambda = c \lambda = -c$.

Taking the scalar product by $\frac{1}{r}$ we find

$$\frac{1}{r} \frac{d}{dt} \left(\frac{r^2}{dt} \right) = 0; \text{ similarly}$$

$$\frac{1}{r} \frac{d}{dt} \left(\frac{r^2}{dt} \right) = 0.$$

Equation (7) shows the rate of description of double areas by the radius vector from sun to planet to be constant ($= c$) and that its motion is in a plane perpendicular to $(l:l_1:l_2) = \lambda$. The direction of this axis is such that an ordinary screw, when made to advance along it, will rotate in the direction of the description of areas.

Taking the second member of (7) with the first member of (4) and *vice versa*, and forming corresponding determinants and integrating, we have

$$(9) \quad c \begin{vmatrix} 1 & l_1 & l_2 \\ \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \end{vmatrix} = \frac{M}{r} (x, y, z) - f(m, m_1, m_2)$$

where $m^2 = m_1^2 + m_2^2 = 1$ and f is positive.

Multiplying (9) by $(1, l_1, l_2)$ and adding, we have $1 \cdot m + l_1 \cdot m_1 + l_2 \cdot m_2 = 0$, or (m, m_1, m_2) is in the plane of motion.

Take $(n, n_1, n_2) = \frac{1}{\sqrt{m^2 + m_1^2 + m_2^2}} \begin{vmatrix} 1 & l_1 & l_2 \\ m & m_1 & m_2 \end{vmatrix}$ forming the direction cosines of a third axis perpendicular to the two already found.

Form with $(1, l_1, l_2)$ and (9) corresponding determinants, and we have:

$$(10) \quad c \begin{vmatrix} \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \\ 1 & l_1 & l_2 \\ m & m_1 & m_2 \end{vmatrix} = \frac{M}{r} \begin{vmatrix} 1 & l_1 & l_2 \\ x & y & z \end{vmatrix} - f(n, n_1, n_2)$$

This is the hodograph. It is a circle [remembering (8)] of radius $\frac{M}{c}$ and center $-\frac{f}{c} (n, n_1, n_2) = -\frac{f}{c} \nu$. The radius of this hodograph is one right angle in advance of the radius vector of the planet to which it corresponds.

Transposing the f terms of (9) to the first member, squaring, and using (6), we have:

$$(11) \quad \frac{c^2 M^2}{a^2} - f^2 = M^2 \text{ or } a = \frac{c^2 M}{M^2 - f^2}.$$

Multiplying (9) into (x, y, z) we have, by adding:

$$(12) \quad c^2 = M r + f(m x + m_1 y + m_2 z).$$

Multiplying the second member of (7) into the first member of (4) and *vice versa* and integrating, we have:

$$c \lambda \frac{d \rho^2}{dt} = \frac{M}{\rho^2} \rho^2 - f \rho$$

where $\rho^2 = f \rho^2 = f$.

Taking the scalar product by λ , we find $S \lambda \rho = 0$, or ρ is in the plane of motion.

Take $\nu = \lambda \rho$ forming the rectangular unit vectors λ, μ, ν .

Multiply (9) by λ and we have:

$$c \frac{d \rho^2}{dt} = \frac{M}{\rho^2} \lambda \rho^2 + f \nu$$

Multiplying (9) into ρ^2 and taking scalars:

$$c^2 = M \rho^2 + f S \mu \rho^2$$

This, remembering (8), is the equation of the orbit. It is a conic whose focus is the sun, and axis is $(m, m_1, m_2) = \mu$. The eccentricity is $e = \frac{f}{M}$, the semi-parameter, $p = \frac{c^2}{M}$. Hence, the semi-major axis is $c^2 M / (M^2 - f^2)$, or a by (11). The center is $-a e (m, m_1, m_2) = -a e \mu$. We may put the orbit, therefore, in the form:

$$r^2 = -a e \mu - \mu a \cos E + b \sin E. \quad e < 1.$$

$$r^2 = -a e \mu + \mu a \cosh E + b \sinh E. \quad e > 1.$$

This substituted in (7) and integrated gives Kepler's equation

$$(13) \quad \begin{aligned} E - e \sin E &= \frac{c}{a b} (t - t_0) & e < 1. \\ E - e \sinh E &= \frac{c}{a b} (t - t_0) & e > 1. \end{aligned}$$

For analytical treatment see Dr. Dzisek's Theories of Planetary Motion, pp. 1-13.

NOTES CONCERNING TESTS OF THE PURDUE EXPERIMENTAL LOCOMOTIVE. By Wm. F. M. Goss.

The Purdue experimental Locomotive Plant was installed early in the present year. It has been fully described in a paper read before the American Society of Mechanical Engineers at its San Francisco meeting, and a brief reference to the plan of mounting must serve the present purpose.

The driving wheels of the locomotive rest upon other wheels which are carried by shafts running in fixed bearings. When, as in the process of running, the drivers turn, their supporting wheels are driven by rolling contact. The locomotive as a whole instead of moving forward, remains at rest while the track, that is, the periphery of the supporting wheels, moves rearward. The locomotive draw-bar is connected with a series of scale-beams which constitute a traction dynamometer. Friction brakes on the shafts of the supporting wheels, interpose a resistance to the turning of the latter and, by so doing, supply a load for the locomotive. The whole arrangement is such that while the locomotive is fired in the usual way, it may be run under any load and at any speed, the conditions being similar to those of the track.

In the spring and early summer of the present year nearly a dozen runs were made. All were of a preliminary nature, the whole apparatus being entirely new, and the attendants unskilled in the management of the complicated mounting machinery.

At the beginning of the present school year the work was taken up anew. The object of the present work is, in general, to determine the performance of the engine under conditions varying, first, as to cut-off and, secondly, as to speed. To this end, five series of six tests each have been arranged, all to be run under a constant pulling load of 2500 pounds. This constancy of load makes the mean effective pressure practically constant for all tests, and the power developed dependent upon the speed. The load lacks but little of being equivalent to 10 horse-power for each mile per hour of speed.

All of the tests of the same series are run at the same speed, but each test varies from the others of the series by a change in cut-off. The second series differs from the first, and the third from the second, and so on, only in a change of speed. The first series at 15 miles per hour, and the second at 25 miles per hour, have already been run, and, in carrying them on, all conditions were as perfectly maintained as could be desired. The remaining series will be at 35, 45, and 55 miles per hour respectively. Every test is complete in itself. The observed data include speed, drawbar stress, coal and water consumption, calorimeter determination, draft and temperature in smoke-box, and cylinder performance as obtained by the use of four indicators. All tests are of three hours duration and are run without intermediate stops or change of speed. A comparison of results, first of the tests of each series, and secondly, of tests of the same cut-off in the different series, cannot fail to furnish an analysis of the performance of the locomotive which will be far more complete than anything hitherto attempted.

THE ELECTROSTATIC THEORY OF COHESION AND VAN DER WAAL'S EQUATION.

By REGINALD A. FESSENDEN.

QUARTZ SUSPENSIONS. By BENJ. W. SNOW.

A THERMO-REGULATOR FOR ROOMS HEATED BY STEAM. By J. C. ARTHUR.

EXPERIMENTS WITH AND PHENOMENA OF VACUUM TUBES. By R. A. FESSENDEN.

THE ELECTRO-MAGNETIC INERTIA OF A LARGE MAGNET. By THOS. GRAY.

SOME NEW ELECTRICAL APPARATUS. By R. A. FESSENDEN.

ON THE CONSTRUCTION AND USE OF A BOLOMETER. By B. W. SNOW.

ROTARY BLOWERS. By JOHN T. WILKIN.

AN INQUIRY AS TO THE CAUSE OF VARIETY IN ROCK DEPOSITS AS SEEN IN HUDSON RIVER BEDS AT RICHMOND, IND. By JOSEPH MOORE.

Take a depth of our bed rock at this place of, say fifty feet, along the river channel. The variations in the lithological character of the numerous sharply defined layers is very marked and very many times repeated; not more so, however, than in hundreds of other localities throughout the country at the same or at other horizons. Here the well solidified portions are thick-bedded (the layers say a foot thick) while not far below or above they are thin, say one or two inches. These consolidated layers vary in texture and composition, some of them being nearly pure limestone and sufficiently crystalline to take a fair polish. Others are masses mainly of brachiopods, often well preserved and matted together with clay or with lime and iron from a state of solution. Others still are shoals of commingled sand, clay and lime and almost destitute of fossils. Then there are the intercalated beds of clay with sufficient calcium carbonate to effervesce with acids for a little while, but leaving their principal bulk when the solvent has done what it can. These beds of finest grained clay vary in thickness from a very few feet to a few inches and even to the thickness of ordinary paper. Often these clay deposits are entirely destitute of fossils and again they are the hope of the hunter of trilobites and a few other form that may be found therein. All these features are familiar to the observer in various localities.

But the commonness of the phenomena does not make their causes the less desirable to seek. It can hardly be supposed that the ocean varied in

depth so many hundred times as would be necessary to produce all the variations to be read in a thickness of five hundred feet. Pure limestones are made in the deeper waters and fine argillaceous sediments may settle in the deeper or the shallower places.

But there appears to be ample reasons for believing that the sea in which the Hudson River rocks of Indiana and Ohio were deposited had its shore line far away, or in other words, said localities were near the middle of a continental ocean.

How then can we account for such well defined successions of mechanical deposits for so long a period of time? How could these sediments get so far from shore and how could they recur so sharply bounded as they are from the purer limestone and other consolidated ledges? How came it about that there were such numerous alternations of life and death epochs in the same fifty, or five hundred feet? The answer to these questions may be very easy to some geologists. We have not, however, seen them satisfactorily answered. Their solution, whatever it is, will be the opening of a door to other secrets.

THE TRAPS OF REDHEAD, N. B. By V. F. MARSTERS.

EXHIBITION AND EXPLANATION OF A GEOLOGICAL CHART. By ELWOOD P. CUBBERLY.

GLACIAL AND PREGLACIAL EROSION IN VICINITY OF RICHMOND, IND. By JOSEPH MOORE.

Richmond is on Drift, underlaid by upper layers of Lower Silurian known as rocks of the Hudson River Group. These rocks being of the earlier time have been above the sea for ages. Consequently there was plenty of time for them to be much eroded. I shall not in this brief paper specify all the well-marked features of erosion but will allude to a few special examples. There is a buried river channel a few rods west of the present channel of Whitewater. This was reported nearly fifty years ago by Dr. Plummer, of Richmond, but it was not then so well known in its extent and direction as it has since become by means of wells, tile layers and ditches for water and gas mains. Said buried channel is about seventy feet wide where crossed by the national road and its walls are very

nearly vertical. In general direction it lies nearly north and south, approximately parallel to the present channel and is of unknown depth. It is filled with sand, gravel, clay and boulders, with remains of leaves and sticks here and there. It is believed to have been rather a new channel when filled since the upper edges of its vertical walls were not worn down and rounded. It may have been, and probably this part of it was, eroded during an interglacial period. There is a much narrower channel at a shorter distance on the east side of the present river channel as exposed by the deepening of Main street leading westward from town.

A feature little, if at all, reported in Indiana, so far as the writer has observed, is that of great "pot holes" or "glacial jugs" or "giant kettles."

A few years since Mr. Starr, the proprietor of the gas works, called me over to see one of these where he was excavating in the solid rock for a very large cistern.

In one of the walls was a section of the "jug." It was some ten feet in diameter and about the same depth was exposed, though it extended deeper than the cistern. It was filled with clean sand and gravel beautifully assorted and stratified and near the lowest part exposed were boulders two feet in diameter finely smoothed and rounded. The walls of this pot hole, which was much the shape of a great jug, were as smooth and polished inside as if the sand and gravel, with the pouring in of a torrent, had been on the whirl for a century. A few years later and about twelve rods from the same place, the city, while cutting into the south wall of Main street near the present river channel in order to widen and straighten the street, struck another jug. This last one was more funnel shaped, but had its sand worn boulders and smooth sides as in the first.

Though not at the southern limit of glaciers in Indiana we are in the line of a terminal morain as indicated by boulders and till. These pot-holes may be the result of the glacier having been stationary or nearly so for a length of time.

As a further phenomenon, lately the matter brought to light by a recent railroad cut, and somewhat in the same connection, may be mentioned a line of masses of Clinton limestone which some have supposed to be outliers in situ. These are about two miles southwest from the central part of Richmond and within five minutes walk of Earlham college.

Recent facts seem to indicate that these masses, jutting out here and there for more than three hundred yards, instead of being outliers and in their original place, are really masses of rock moved on for miles by the

glacier. (It is but a few miles north to where Hudson River rock dips under upper silurian.) Evidences that they are masses of Drift are found in the irregular way in which the rocks lie at all angles, and in the fact that where the lower rock is exposed in the cut the under side is glaciated as if by moving over other rocks.

RELATION OF KINGS COUNTY TRAPS TO THOSE OF CUMBERLAND COUNTY, N. S.
By V. F. MARSTERS.

AN ACCOUNT OF VEGETABLE AND MINERAL SUBSTANCES THAT FELL IN A SNOW
STORM IN LA PORTE COUNTY, JAN. 8-9, '92. By A. N. SOMERS.

SOME POINTS IN THE GEOLOGY OF MT. ORIZABA. By J. T. SCOVELL.

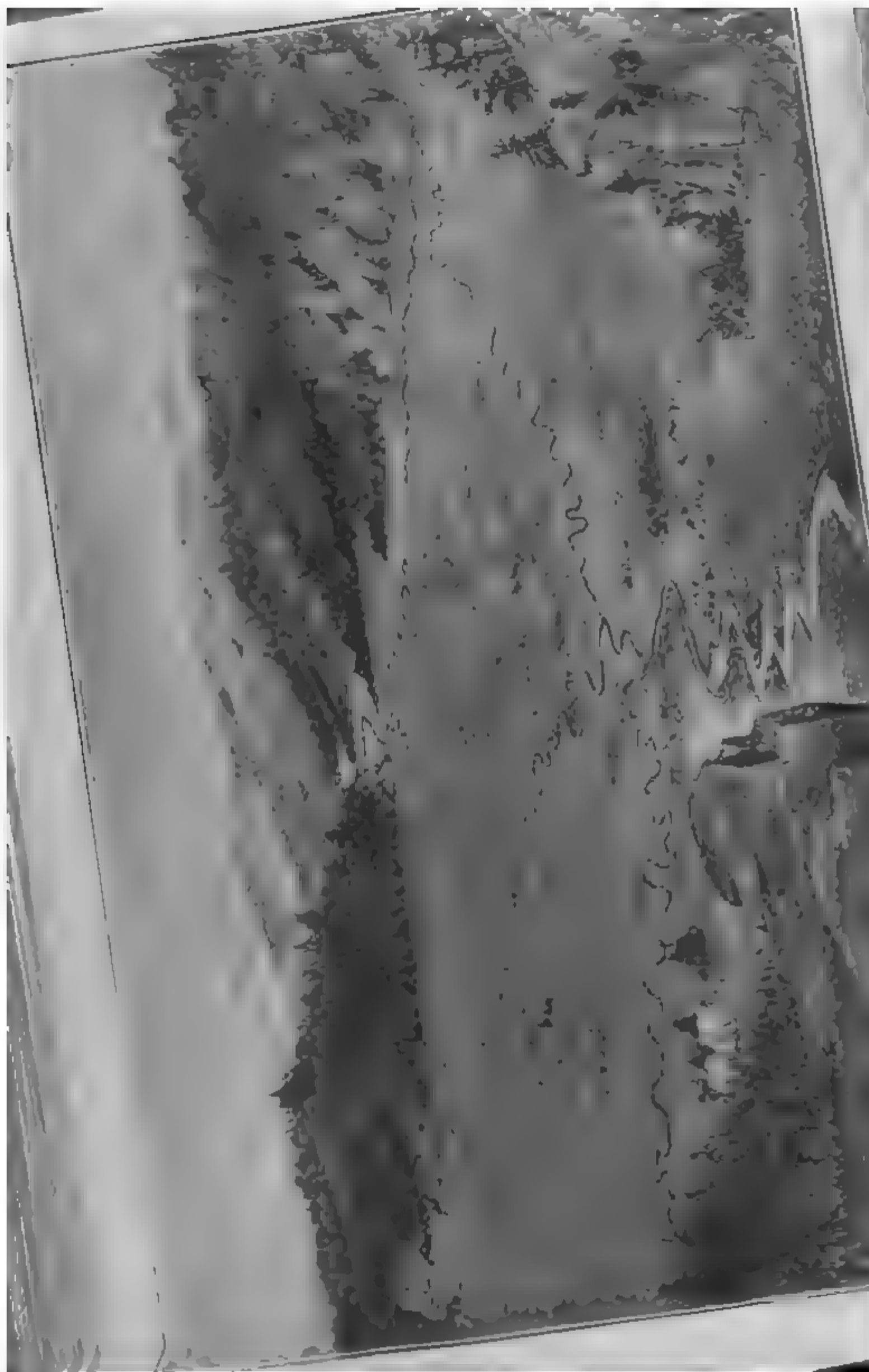
BRITISH COLUMBIA GLACIERS. By C. H. EIGENMANN.

An account was given of the ascent of "The Glacier" in the Selkirks in British Columbia. A number of photographs were shown of the foot of the glacier.

TWO-OCEAN PASS. By BARTON W. EVERMANN.

[ABSTRACT.]

It was probably in Pliocene times that the great lava-flow occurred in the region now known as the Yellowstone National Park, which covered hundreds of square miles of a large mountain valley with a vast sheet of rhyolite hundreds, perhaps in places, thousands of feet thick. It is certain that such streams and lakes as may have existed there were wiped out of existence, and all terrestrial and aquatic life destroyed. It must have been many long years before this lava became sufficiently cooled to permit the formation of new streams; but a time finally came when the rains,



falling upon the gradually cooling rock, were no longer converted into steam and thrown back into the air, only to condense and fall again, but being able to remain in liquid form upon the rock, sought lower levels, and thus new streams began to flow. The rhyolite, obsidian, and trachyte were very hard and eroded slowly, but when the streams reached the edge of the lava-field they encountered rock which was comparatively soft and which wore away rapidly. The result is that every stream leaving the Yellowstone Park has one or more great waterfalls in its course where it leaves the lava-sheet. Notably among these streams are Lewis River, the outlet of Lewis and Shoshone lakes, Yellowstone River, the outlet of Yellowstone Lake, Gardiner, Gibbon, and Firehole rivers, and Lava, Lupin, Glen, Crawfish, Tower and Cascade creeks, all leaving the lava-sheet in beautiful falls, varying from 30 feet to over 300 feet in vertical descent. With scarcely an exception, all these streams and lakes are of the best of pure, clear, cold water, well supplied with insect larvæ, the smaller crustacea, and various other kinds of the smaller animal and plant forms sufficient in amount to support an immense fish-life. But it is a strange and interesting fact that, with the exception of Yellowstone Lake and River, these waters were wholly barren of fish-life. The river and lake just named are well filled with the Rocky Mountain trout (*Salmo mykiss*), and this fact is the more remarkable when it is remembered that the falls in the lower Yellowstone River are 109 and 308 feet, respectively, by far the greatest found in the Park.

The total absence of fish in Lewis and Shoshone lakes and the numerous other small lakes and streams of the Park is certainly due to the various falls in their lower courses which have proved impassable barriers to the ascent of fishes from below; for in every one of these streams just below the falls trout and, in some cases, other species are found in abundance. But to account for the presence of trout in Yellowstone Lake was a matter of no little difficulty. If a fall of 30 to 50 feet in Lewis River has prevented trout from ascending to Lewis and Shoshone lakes, why have not the much greater falls in the Yellowstone proved a barrier to the ascent of trout to Yellowstone Lake? Certainly, no fish can ascend these falls and we must look elsewhere for the explanation.

Many years ago the famous old guide, Jim Bridger, told his incredulous friends that he had found on the divide west of the Upper Yellowstone a creek which flowed in both directions: one end flowing east into the Yellowstone, the other west into Snake River. But as he also told them

about many other strange, and to them impossible things which he had seen, among which were a glass mountain, and a river which ran down hill so fast that the water was made boiling hot, they were not disposed to acknowledge the existence of his "Two-Ocean Creek." Subsequent events, however, showed that the strange stories of Jim Bridger were not without some elements of truth.

Two-Ocean Pass was visited by Capt. Jones in 1873, by Dr. F. V. Hayden in 1878, and by Mr. Arnold Hague in 1884. The observations made by these various explorers seemed to indicate that Two-Ocean Pass is a nearly level meadow, near the center of which is a marsh which, in times of wet weather, becomes a small lake, and that "a portion of the waters from the surrounding mountains accumulate in the marshy meadows and gradually gravitate from either side into two small streams, one of which flows to the northeast, the other to the southwest." (*Hayden.*)

From these reports it began to be suspected that trout, ascending Pacific Creek from Snake River, might in time of high water, pass through the lake in Two-Ocean Pass and descend Atlantic Creek and the Upper Yellowstone to Yellowstone Lake, and thus would the origin of the trout of that lake be explained. Dr. Jordan, who spent some time in the Park in 1889, was impressed with the probable correctness of this explanation, but did not visit Two-Ocean Pass.

In 1891, while carrying on certain investigations in Montana and the Yellowstone Park under the direction of the United States Commissioner of Fish and Fisheries, Colonel Marshall McDonald, I was instructed to visit Two-Ocean Pass and determine definitely the conditions which obtain there.

On August 7, accompanied by Dr. O. P. Jenkins and Mr. Burnside Clapham, we started out from Mammoth Hot Springs with a pack-train of ten pack-horses and eight saddle-horses. Our route led us through all the Geyser Basins of the Park and we reached Two-Ocean Pass August 17, where we remained long enough to make a careful examination. This pass is a high mountain meadow, about 8,200 feet above the sea and situated just south of the Park, in long. $110^{\circ} 10'$, lat. $44^{\circ} 3'$. It is surrounded on all sides by rather high mountains except where the narrow valleys of Atlantic and Pacific creeks open out from it.

Running back among the mountains to the northward are two small cañons, down which come two small streams. On the opposite side is another cañon, down which comes another small stream. The extreme

length of the meadow from east to west is about a mile while the width from north to south is not much less. The larger of the streams coming in from the north is Pacific Creek, and, after winding along the western side of the meadow, turns abruptly westward, leaving through a narrow gorge. Receiving numerous small affluents, Pacific Creek soon becomes a good-sized stream, which finally unites with Buffalo Creek a few miles above where the latter stream flows into Snake River.

Atlantic Creek was found to have two forks entering the Pass. At the north end of the meadow is a small wooded cañon down which flows the North Fork. This stream hugs the border of the flat very closely. The South Fork comes down the cañon on the south side, skirting the brow of the hill a little less closely than does the North Fork. The two coming together near the middle of the eastern border of the meadow form Atlantic Creek which, after a course of a few miles, flows into the Upper Yellowstone. But the remarkable phenomena exhibited here remain to be described.

Each fork of Atlantic Creek, just after entering the meadow, divides as if to flow around an island, but the stream toward the meadow, instead of returning to the portion from which it had parted, continues its westerly course across the meadow. Just before reaching the western border the two streams unite and then pour their combined waters into Pacific Creek; thus are Atlantic and Pacific Creeks united and a continuous water way from the mouth of the Columbia via Two-Ocean Pass to the Gulf of Mexico is established. Two-Ocean Creek is not a myth but a verity, and Jim Bridger is vindicated.

Pacific Creek is a stream of good size long before it enters the pass, and its course through the meadow is in a definite channel, but not so with Atlantic Creek. The west bank of each fork is low and the water is liable to break through anywhere and thus send a part of its water across to Pacific Creek. It is probably true that one or two branches always connect the two creeks under ordinary conditions, and that following heavy rains or when the snows are melting a much greater portion of the water of Atlantic Creek finds its way across the meadow to the other.

Besides the channels already mentioned, there are several more or less distinct ones that were dry at the time of our visit. As already stated, the pass is a nearly level meadow, covered with a heavy growth of grass and many small willows 1 to 3 feet high. While it is somewhat marshy in places it has nothing of the nature of a lake about it. Of course during

wet weather, the small springs at the borders of the meadow would be stronger, but the important facts are that there is no lake or even marsh there and that neither Atlantic nor Pacific Creek has its rise in the meadow. Atlantic Creek, in fact, comes into the pass as two good-sized streams from opposite directions and leaves it by at least four channels, thus making an island of a considerable portion of the meadow. And it is certain that there is, under ordinary circumstances, a continuous waterway through Two-Ocean Pass of such a character as to permit fishes to pass easily and readily from Snake River over to the Yellowstone, or in the opposite direction. Indeed, it is possible, barring certain falls in Snake River, for a fish so inclined to start at the mouth of the Columbia, travel up that great river to its principal tributary, the Snake, thence on through the long, tortuous course of that stream, and, under the shadows of the Grand Tetons, enter the cold waters of Pacific Creek, by which it could journey on up to the very crest of the Great Continental Divide, to *Two-Ocean Pass*; through this pass it may have a choice of two routes to Atlantic Creek in which the down-stream journey is begun. Soon it reaches the Yellowstone down which it continues to Yellowstone Lake, then through the Lower Yellowstone out into the turbid waters of the Missouri; for many hundred miles it may continue down this mighty river before reaching the Father of Waters which will finally carry it to the Gulf of Mexico—a wonderful journey of nearly 6,000 miles, by far the longest possible fresh-water journey in the world.

We found trout in Pacific Creek at every point where we examined it. In Two-Ocean Pass we found trout in each of the streams and in such positions as would have permitted them to pass easily from one side of the divide to the other. We also found trout in Atlantic Creek below the pass and in the Upper Yellowstone where they were abundant.

Thus it is certain that there is no obstruction even in dry weather to prevent the passage of trout from the Snake River to Yellowstone Lake; it is quite evident that trout do pass over in this way; and it is almost absolutely certain that Yellowstone Lake was stocked with trout from the west via Two-Ocean Pass.

GRINNELLIA AMERICANA. By M. A. BRANNON.

Grinnellia Americana is one of the most interesting and beautiful marine plants found along our Atlantic coast. So far as known, it ranges

only from Cape Cod to New Jersey, abounding chiefly in the shore waters of Long Island sound and New York harbor.

This alga attains a length of 50 cm. and a breadth of 10 cm., but this is an unusual size. The ordinary specimen would not exceed 20 cm. in length and 5 cm. in breadth.

This plant attaches itself to the piles of wharves, pieces of decayed wood, and rarely grows on stones and shells. It grows most abundantly 6 to 10 feet below low tide mark. It is a dioecious plant, and also has a non-sexual method of reproduction. The antheridia are small, nearly transparent dots promiscuously distributed in the tissue of the thallus. When liberated, in salt water, the antherozoids are quite active, and while they were not observed fertilizing the female organ, it is safe to affirm that they accomplish a union with the female portion of the plant in the way common to algae.

The female organ—the cystocarp—is jug shape, with a prominent orifice. The cystocarps are found equally distributed on the surfaces of the thallus which is one cell thick. The interior of the cystocarp is very complicated. It develops from an apical cell. This further testifies that Dr. Schmitz's theory of the origin of the reproductive organs of the red alga is true—namely, they are terminal growths, or branches of the frond.

Experiments in germinating spores were quite successful. Carpophores were cultivated for several days in salt water. Cell division was rapid and there were young filaments developed containing 16 to 20 cells. The study of spore germination and the development of the young plant is to be continued.

BOTANICAL FIELD WORK IN WESTERN IDAHO. By D. T. MAC DOUGAL.

As may be seen by reference to the map, a large proportion of the state of Idaho consists of a triangular mountain mass, with its greatest length from north to south, reaching in places an elevation of 14,000 to 15,000 feet, and including on its eastern border the Bitter Root, Coeur d' Alene and Rocky Mountain ranges.

Botanical explorations have been carried on in the valley of Clark's Fork of the Columbia to the eastward in Montana, in the basin of the

Snake River in southeastern and southern Idaho, to the westward in the Columbian plain in Washington, and in the northern part of Idaho, where the Clark's Fork of the Columbia cuts its way westward through the mountains, but this great central labyrinth is as yet an unknown land to the botanist, nor is he behind his brother zoologist in this matter.

With the purpose of beginning a systematic survey that should finally include this whole region, Messrs. J. H. Sandberg, A. A. Heller and myself, acting under the direction of the Botanical Division of the Department of Agriculture, undertook at the beginning of the last season the exploration of a portion of this territory along the western border of the mountain ranges.

In accordance with this plan, we took the field with a camp outfitted at Lewiston, at the head of navigation of Snake river, in the latter part of April, and worked southward till we struck the Craig Mountains, then swinging around northward, followed the line where the foot hills run down to meet the plain, across the basins of the Clearwater and Palouse rivers, Lake Coeur d' Alene, and Clark's Fork of the Columbia river at its expansion into Lake Pend d'Oreille.

This route was chosen because it offered easy access to widely differing areas. To the westward lay the basaltic Columbian plains, with an elevation of 700 to 2,500 feet, with its vegetation made up of plants peculiar to the Pacific coast flora; to the eastward, rising in successive tiers, were the secondary ranges, composed of trachyte, limestone, quartz and granite, reaching an elevation of 7,000 feet, with its wide range of plants comprised in the Rocky Mountain flora.

The difference between these two areas is still further heightened by the peculiarities of the climate. The basaltic plain, during the rainy season, which ends in the latter part of May, supports a dense growth of succulent, broad leaved, rapid growing plants, which mature very early. With the close of the rainy season, the soil dries into dust in a very few days, the earlier growth dies, and is replaced by hardy, coarse, narrow-leaved forms which are capable of enduring the extreme heats of the summer. In the mountains, however, the water supply coming from melting snows and springs is more equable, and we have a greater number of plants which endure throughout the season.

The flora of both regions is characterized by extreme localization. The limits within which a large percentage of the species were collected often comprised no more than a few square yards or a few acres. As examples

may be given *Mimulus cardinalis*, *Castalia Leibergii*, *Corydalis aurea*, *Polygonum Kelloggii*.

Although the mountain region is very rich in Algae Lichens Mosses and Hepatics, the conditions for work and character of our outfit made it necessary to confine our attention almost wholly to the Phanerogams and Pteridophytes, although a few lower forms were collected.

In all, ample material of about 1,000 species was brought in, which is fairly representative of the region explored.

THE APPLICATION OF MATHEMATICS IN BOTANY. BY KATHERINE E. GOLDEN.

The tendency in the sciences is toward reducing results and conclusions to exactness, as far as possible, and this is as true for botany as for any of the so-called exact sciences. The tendency being toward precision, naturally the use of mathematics is becoming more general in all the sciences, in the solution of problems and the expression of results.

In physiological botany, especially, the use of mathematics is very applicable, for a great many of the principles of physiological phenomena are reducible to the principles of physics and chemistry, which are represented by mathematical formulae, and when so represented, the conception of the phenomena is simplified, and is divested of much of the mysteriousness that attaches to it, as fundamental principles are often easier of comprehension when reduced to mathematical formulas. For instance, in studying the absorption of gases by plants, there are so many factors that enter the solution of the problem that the subject is complex to a great degree, but when it is known that the amount of gas dissolved from a mixture is proportional to the relative volume of it in the mixture multiplied by its coefficient of solubility, the quantities of gases that can be dissolved by the cell-sap are known, and a definite basis is obtained from which to start, and to take into consideration other conditions.

To show the estimate that Francis Galton* places on the laws governing the life of plants, in his work on "Natural Inheritance," in trying to arrive at some measurable characteristic by which to determine the reason for the statistical similarity shown in successive generations, he used sweet peas with which to experiment, separating them into groups ac-

*Francis Galton. *Natural Inheritance*. 1889, pp. 79-82.

ording to size. The experiments were satisfactory, as they gave him the data which he sought, thus enabling him to solve the problem.

That the tendency of botanical work is in the direction of mathematical preciseness is seen in the works of Sachs, Nägeli, Wiesner and many others. Sachs* has worked out cell division in a masterly manner. By means of periclined and anticlined planes he has demonstrated the direction of the cell-divisions in a growing organ, the outline of the organ taking the form of a parabola, a hyperbola, or an ellipse. By this means he has proven that the mode of cell-division depends entirely upon the increase in volume and the configuration of the growing organ, and not upon its physiological or morphological significance. From his work he has formulated two important laws, (1) that the daughter-cells are usually equal to one another in volume, and (2) that the new cell-walls are situated at right angles to those already present.

Previous to Sachs' work it was supposed that it was possible to characterize the true morphological or phylogenetic nature of an organ by the way in which cell-division took place.

Sachs has also studied the growing apex of stems and roots so as to determine the zone of greatest growth. From the tables compiled by him there are certain facts deduced which, when the successive zones are represented by A, N, $N+x$, the apical zone being A, the zone of greatest growth N, and the last zone of the growing region $N+x$, are clearly expressed by the formula:

$$A < A+1 < A+2 \dots < N > N+1 > N+2 \dots > N+x.$$

The formula indicating the relation of their respective increments.

The following general expression is used by Sachs to express the relative lengths of the different tissues after isolation, where E, C, V, P, stand respectively for epidermis, cortex, vascular tissue and pith:

$$E < C < V < P > V > C > E.$$

The expression also states the relation active tension of the layers, for the greater the compression, the greater will be the length upon isolation.

Nägeli† has demonstrated the movements of bacteria in air and water. He classifies them into groups and applying the general formula for velocity $v = \sqrt{2gh}$, he has deduced the formulæ $v = \sqrt{\frac{2ghr}{r}}$ in which h is

*J. Sachs. Arbeiten des bot. Inst. in Würzburg, 1878. On the Physiology of Plants. 1887, pp. 431-459.

†C. v. Nägeli. Untersuchungen über niedere Pilze aus dem Pflanzenphysiologischen Institut in München. 1882.

the middle vertical diameter of the body, r_1 is the specific gravity of the body, and r the specific gravity of the fluid for the movement in air

$$v = \frac{1}{r} \sqrt{2gh(r_1 - r)}$$
 for the movement in any liquid.

Wiesner* has done a great deal of work in determining the application of the laws for different gases to epidermis with and without openings, at the atmospheric pressure, and pressures above and below that of the atmosphere, and with dead and living, dry and moist membranes. He has made sufficient experiments so that his conclusions, which are expressed by mathematical formulae in many cases, are general, that is, his formula $\frac{A}{d}$ in which A represents the absorption coefficient, and d the density of the gas is general for the epidermis, free from stomata, of any plant.

An application of mathematics that one does not often see outside of the statistician's work was made by Dr. Arthurt in his work on pear blight. In this there was a set of determinations made as to the succulency of the fruit of the Buffum pear, so as to note the relation between the amount of moisture and the extent of the blight. After the determinations were made, calculations of the probable error in the results were also made, finding the variation in the determinations, and the extreme variation from the mean; using the figures and applying the formula,

$$= .6745 \sqrt{\frac{s}{n}}$$
 in which s is the sum of the squares of the differences between each separate observation and the average of all, and n is the number of observations. This work was done to prove its correctness, as the accuracy of such work had been questioned.

The most general application of graphic mathematics is the rectilinear system of coördinates. This is so simple in the construction of diagrams and so readily understood that a great many people make use of it. Besides, one diagram will show the relation among different sets of data. Take, for example, one of Sachs' diagrams showing plant growth. The abscissa represents increments of time, the division of the ordinates, the increments in length, the axis of abscissa represents a certain temperature, and a certain number of the divisions of the ordinates represent a degree a temperature. Then spaces of the diagram are shaded for night. The

*J. Wiesner. Versuche über den Ausgleich des Gasdruckes in den Geweben der Pflanzen, 1879. J. Wiesner und H. Molisch. Untersuchungen über die Gasbewegung in der Pflanze, 1889,

†J. C. Arthur. 5th Ann. Rep. N. Y. Exp. Sta., 1886, pp. 284-285.

curves of growth and temperature are represented on the same diagram, so that one can easily tell the increment of growth for a given time along with the factors of heat and light. This kind of diagram is especially valuable if the experiment be written in a language that one does not read readily, for the gist of the work can be gotten from the diagram with but little help from the text.

A great deal of mathematical work has been done in phyllotaxy. This work consisted in the first place in imagining a line proceeding from one of the older lateral members, traversing the stem to right or left, so as to include the points of insertion of all the successive lateral members in the order of their age. This line, when projected, horizontally, was called the genetic spiral, but as the line is a helix, its horizontal projection could not be a spiral.

Then in working out the law of the phyllotaxis, a series of fractions were formed, the numerator expressing the number of complete revolutions round the stem, starting from the point of insertion of a lateral organ and extending to the organ directly above it; the denominator expressing the number of joints of insertion of lateral organs passed through. It was discovered that the series of fractions expressing the most common divergences were successive convergents of the continued fraction.

$\frac{1}{2+\frac{1}{1-\frac{1}{1-\frac{1}{\ddots}}}}$

and it was supposed that a natural law had been found, but as it is necessary to construct new continued fractions for many of the divergences, this proved fallacious. But $\frac{1}{1+\frac{1}{\ddots}}$ etc. as no relation has been found to exist between the method and anything relating to plant life, the method has but little value, except from the mnemonic point of view. Work on this subject was very popular about twenty years ago, as it gave people an opportunity of proving that they knew their mathematics, it being somewhat generally supposed at the time that anyone who could do his mathematics could easily do his other work.

In the latest bulletin* issued from the Ind. Exp. Sta., the subject of which is the relation of number of eyes on the seed tuber to the product, it was found that a relation existed between the eye of the seed tuber and the number of stalks, that is, when the eyes formed an arithmetical series, the number of stalks, per unit of weight, derived from them formed an approximate hyperbolic series. To a scientific person this result means

J. C. Arthur. Purdue Exp. Sta. Ind., No. 42, 1892.

much, for the results are definite and given in the briefest and yet the most comprehensive manner.

When engineers publish results of experiments, they express the conditions for, and the results of, their experiments by means of mathematical formulae as much as possible, and the tendency among botanists is to the same practice, for with the great amount of literature that is published annually, the putting the gist of the matter into the most concise and comprehensive form is becoming indispensable.

ON THE FERTILIZATION AND DEVELOPMENT OF THE EMBRYO IN *SENECIO AUREUS*.
By D. M. MOTTIER.

DISTRIBUTION OF THE NORTH AMERICAN CACTACEAE. By JOHN M. COULTER.

MARCHANTIA POLYMORPHA, NOT A TYPICAL OR REPRESENTATIVE LIVERWORT.
By L. M. UNDERWOOD.

HOW A TENDRIL COILS. By D. T. MACDOUGAL.

FORESTRY EXHIBIT OF INDIANA AT THE COLUMBIAN EXPOSITION. By STANLEY COULTER.

NOTES ON CERTAIN PLANTS OF SOUTHWESTERN INDIANA. By JOHN S. WRIGHT.

This report is based upon about two weeks of field work done during the latter part of September, 1892, in the extreme southwestern part of the state, by D. T. MacDougal and J. S. Wright. This region is known as the "pocket" and owing to its peculiar peninsular position has an overlap of a northern and a southern flora.

Notes were made upon the distribution and condition of nearly 200 forms.

Report was made upon a depauperate form of *Bideus ceruna* L., found on the Wabash banks.

Among the forest trees special notes were made upon distribution, size, &c., of *Celtis mississippiensis* Bosc.; *Carya oliviformis* Nutt; *Quercus lyrata* Walt.; *Diospyros virginiana* L., and *Taxodium distichum* Richard.

EPIDERMIS AND SPINES OF CACTACEÆ. By E. B. ULIN.

Before entering upon the revision of Cactaceæ now in preparation under President Coulter's direction at Indiana University, a series of investigations on the minute structure of such material as was then available was made during the winter and spring terms of 1892. It was our purpose not only to learn of the general morphological nature of the family, but also to discover, if possible, any new diagnostic characters that might be of service in the revision. I have therefore selected for presentation only such peculiarities of structure as may prove of most use in specific determination.

Though nearly a year had passed since the collection of the material, it was still green and in good condition, with tissues fresh and distended as in growing specimens—thus making it highly favorable for study. Sixty-five species were examined, represented generically in the following proportions: *Mamillaria*, 17; *Echinocactus*, 16; *Cereus*, 21; *Opuntia*, 11.

The most striking feature at first sight is the entire absence of true foliage. Naturally, my first inquiry was for some specialized organ or region which should represent, and perform the functions of the missing foliage. The even distribution of stomata and chlorophyll over the entire surface declares the plant itself to be one gigantic and curious leaf so far as function is concerned. However, regarding leaves as devices for increasing surface exposure (expansion of surface formed by the ultimate branching of the fibro-vascular system), I was led to look to the wart-like mamillæ of the genus *Mamillaria*, and to the tubercles and ribs of *Cereus*, *Echinocactus* and certain species of *Opuntia* as the homologues of leaves. Transverse sections of the tubercles of *Mamillaria macromeris* show fibro-vascular branching similar to that of the leaf,—the chief difference lying in the cylindrical nature of the one as distinct from the flat surface of the other. This conclusion is verified by the position of the flowers and branches, which in nearly all cases proceed from the axils of the tubercles and mamillæ. The genus *Opuntia* alone is described as having leaves.

The minute, subulate, early deciduous leaves of this genus furnish the nearest approach to true leaves found among our native species.

In all the specimens examined, true epidermal and hypodermal regions occur in sharply defined outline. The cuticular layer is generally thickened and is clearly distinguished from the true epidermal walls. It becomes thinner as it nears the stoma, and is easily traced into the air chamber (?) It completely lines this respiratory cavity, and, as Von Mohl shows, it even sends out open tubes into the adjoining inter-cellular spaces. The range in thickness passes from the very thin, almost imperceptible form seen in *Mamillaria macromeris* to the astonishing thickness of that seen in *Mamillaria (Anhalonium) prismatica*, where the cuticle is fully ten times the thickness of the true epidermal layer underneath. The stoma in this species communicates with the outer air by a chimney-like canal extending upward and outward through the cuticle. This canal or chimney is beset at three different elevations by sets of four flap like projections which extend out from the wall in such manner as to almost entirely close the orifice. I have failed to find anywhere any mention of these projecting appendages, but conclude that their function is undoubtedly that of accessory guard cells of the stoma. They readily expand on application of moisture, which fact in itself is sufficient evidence of their purpose. The outer wall of the true epidermis in this species barely reaches an average development; while the hypodermal region consists of but one layer of moderately thick-walled narrow cells. The only remaining feature of the cuticle worthy of note as a diagnostic character is the undulation of surface, which is displayed in certain species. Prominent elevations occur in *Cereus Greggii*, *Cereus horizonthalonius*, var. *centrospinus*, and in *Echinocactus polycephalus*.

Definitive characters in the true epidermis are not abundant; but, when they do occur, they are distinct and unmistakable. Three species of *Opuntia* show tangential (?) partitions in the epidermis, breaking it up into two or more rows. *Opuntia phaeacantha* has its epidermis thus thrown into eight rows of exceedingly thin-walled cells. A new species of *cereus* (as yet unpublished) has as high as nine rows of this thin-walled epidermis. Species having two layers are *Echin. polycephalus*, three unnamed species of *Cereus* from San Louis Potosi, Mex., and a new species of *Cereus* from Casa Grande, Ariz. The most curious epidermis in the entire collection is that of *Echin longihamatus*. Since there is nothing like it in the entire number observed, it is well deserving of more than passing at-

tention. In other specimens, the epidermal cells when elongated lie in a parallel direction with the line of outer surface. In this case, they are elongated at right angles to the outer surface. Their thread-like walls are contiguous with the cuticle on the outside; while, on the inside, they are bounded by a single hypodermal row. Their only apparent outer wall is the thickened cuticle.

The hypodermal regions seen may be at once divided into two classes. Those of the first and larger class may be characterized as follows: cells irregular, in several layers: walls thick, pitted, collenchymatous. The second class, on the other hand, are thin-walled, regular, and disposed in one layer. Six *Mamillariae* and five *Cerei* will fall under this latter class. The highest number of collenchyma layers is nine, found in *Cereus grandiflora*. The number of rows, shape of cells and relative thickness of walls appear to be constant within the limits of species, and may be of service as determinative characters.

It remains only to mention the calcium oxalate crystals, which are often distributed as constituents of the cell-contents, both in the epidermal and in the hypodermal tissue. These occur in the form of simple, solitary, klino-rhombic crystals, or more frequently in angular, stellate groups. In size, form and position they vary exceedingly, but appear uniform within the limits of the same species. Crystals occurred in every *Opuntia* and in every *Echinocactus* examined. In *Mamillaria* they were frequent, while in *Cereus*, they were with one exception entirely wanting.

The minute structure of the spines is exasperatingly uniform. The outer, or epidermal cells are usually large and thin-walled, while in the body of the spine the walls are so thick as to entirely close the cell cavities, as is the case in all dense woody tissues. Often there is a gradual transition from one to the other. The important characters are in the outer row of cells. Rough projections partaking of the nature of trichomes, and extending toward the spine tip are common in *Cereus* and *Echinocactus*. In *Mamillaria* the spines are smooth or rarely pubescent, as in *M. pusilla*, *Grahami* and allied forms. Those of the cylindrical and clavate groups of *Opuntia* are without exception clothed with a semi-transparent, glistening sheath; while those of the flat-jointed *Opuntias* are naked. Characteristic of *Opuntia* spines is the conical arrangement of fibers, distinctly seen with the low power objective. Spine fibers of other genera are usually parallel from base to tip, whereas here they are conically arranged with the summits of the cones at the extreme tips and

their bases communicating with the sheath to the rear of the tip and adjacent to it. When the sheath separates from the spine (which happens very early), these ends of the fibers at the base of the cones are slightly lifted from the surface of the spine, forming sharp barbs extending backward on the surface near the tip. This conical barbed structure is likewise common to the sheathless, flat-joint *Opuntias*, and extends even to the minute and much-dreaded bristles of the same genus. It is this property of conical arrangement that makes the prickly pear group the terror of all who have made its acquaintance.

While many of the characters brought to light in these investigations are artificial as must naturally result in tissues so responsive to environment as epidermal structures, the constancy of character within the same species, together with the requisite variation in features presented by different species, can not but be of service to those engaged in a critical study of the family.

THE GENUS CACTUS. By E. M. FISHER.

The genus *Cactus*, as it stands at present, consists of about 350 species and varieties from North America, of which only twenty-five species and seven varieties have been reported from the United States. All these forms are small, ranging from one half to three inches in diameter, and are distinguished by their disconnected tubercles.

In this paper it is proposed to consider briefly the history of the genus, and the classification of its species. To give an accurate and satisfactory history of this genus or any of the genera of *Cactaceæ* is a very difficult thing, because of the meager descriptions and the scarcity of early literature. Taking 1753 (the date of the first edition of Linnaeus' "*Species Plantarum*") as our datum-line, and tracing both backwards and forwards, we reach the following results: In this first edition of the "*Species Plantarum*," Linnaeus published all the *Cactaceæ* with which he was acquainted under one genus, *Cactus*, which he subdivided into four groups called *Echinomelocactus* (subrotund), *Cerii* (erect, angular), *Cerii* (creeping with lateral roots), and *Opuntia* (jointed, compressed, proliferous). Previous to this (1737), in the first edition of the *Genera Plantarum*, Linnaeus published *Cactus* as embracing the genus *Cereus* of Jussieu's *Acta Gallorum* (1719), and *Opuntia* and *Melocactus* of Tournefort's *Institutiones* (1719). *Melocactus*

of Tournefort, in which we are interested at present, is equal to *Ficoides* or *Ficus* of Commelinus' Hortus Amstel (1697), equal to *Ficoides* or *Ficus* of Plukinet Almag. Botanica (1696), equal to *Echino-melocactus* of Hermannus Hortus Lugdbt. (1687).

Commencing again with Linnaeus (1753), we find that he first described the species *Cactus mamillarius*, which thus seems to stand as the type of the genus. This genus of 28 species was not disturbed until 1812, when Haworth, in his Synopsis Plantarum succulentarum, separated it into five genera, *Mamillaria*, *Echinocactus*, *Melocactus*, *Cereus*, and *Opuntia*, discarding Linnaeus' name, *Cactus*. He called *Cactus mamillarius* Linn. *Mamillari simplex* Hawworth, which was the only species of Linnaeus that would fall in the new genus *Mamillaria*. At this time (1812), *Mamillaria* consisted of five species. In 1830 eight species were recognized. This state of affairs was not molested until last year, when Dr. O. Kuntze published his Revisio Genera Plantarum and re-established the Linnaean genus *Cactus*, which thus equals *Mamillaria* Haworth, changing over 300 species of *Mamillaria* to the genus *Cactus*. In summary, we have *Cactus* L., re-established by O. Kuntze (1891), *Mamillaria* Haworth (1812), *Cactus* L. (1753), *Melocactus* Tourn. (1719) in part, *Ficoides* or *Ficus* Commelinus (1697), *Ficoides* or *Melocactus* Plukinet (1796), *Echino-melocactus* Hermannus (1687).

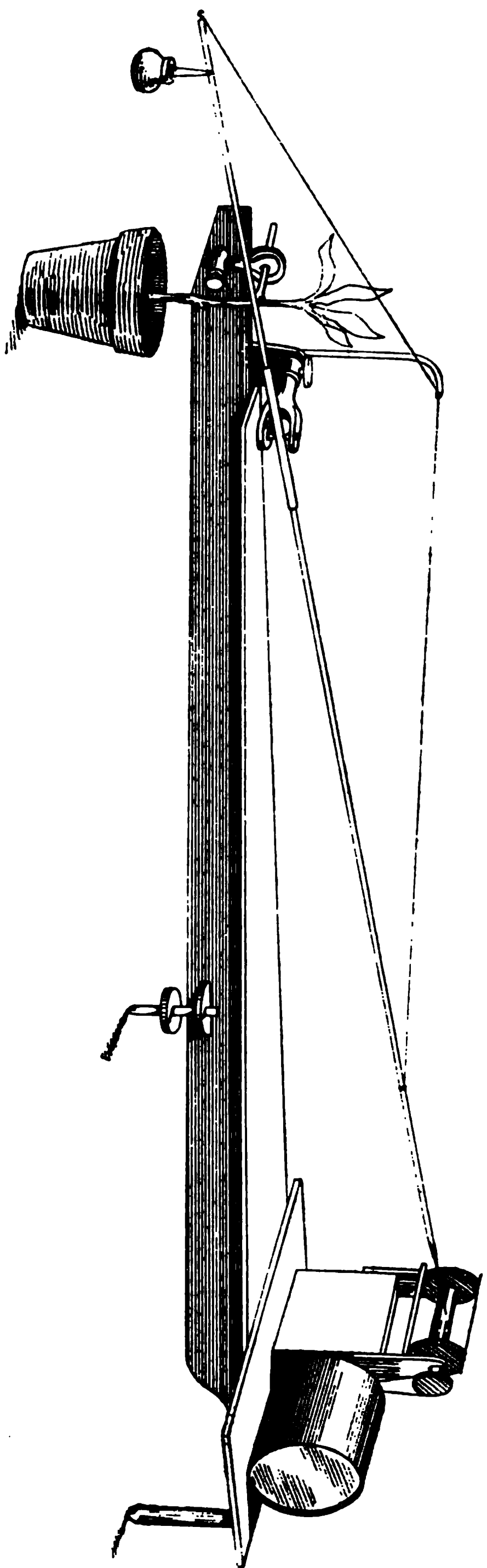
The revision of the genus *Cactus*, like the other genera of Cactaceæ, is made under great difficulties, because of the lack of types, and insufficient flowering material. Since this is true, and because a specimen is almost useless without flowers, according to the present system of keys, we have attempted with the types at command to revise the genus without using flower characters but by using those parts of the plant which are always present, the tubercles and spines.

SOME CAUSES ACTING PHYSIOLOGICALLY TOWARD THE DESTRUCTION OF TREES IN CITIES. By J. C. ARTHUR.

AN AUXANOMETER FOR THE REGISTRATION OF THE GROWTH OF STEMS IN THICKNESS. By KATHERINE E. GOLDEN.

The main feature of this auxanometer for measuring growth in thickness is a balanced glass arm, supported near one end. The long end has a bristle fastened to it that comes in contact with a blackened glass rod carried round on a brass spool, the spool being revolved by a clock.

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THE AIR VANNOMETER.

(Plate loaned by the publishers of the *Journal of Chemistry*.)

The glass arm is supported in a short glass tube that is held between two hardened steel points, the points being adjustable through the arms of a brass *y*. Close behind the steel points is a small fork; this fork, with the glass arm embraces the stem of the plant, the fork permitting an adjustment for large or small stems. These pieces of mechanism are supported by a long wooden beam, that has a beveling near the end supporting the arm. This adjustment is to accommodate plants of varying height.

At the long end of the glass arm, and supported by the beam, is a small wooden platform that in turn supports the revolving spool. The axis of the spool is extended at one end beyond its supports, and carries a grooved pulley, which is connected with a similar grooved pulley attached to the hour hand spindle of the clock by means of a small rubber band. The friction between the rubber and the grooved pulleys, and the uniform tension obtained, precludes slipping.

The way the instrument is used is to place the stem of the plant between the fixed fork and short arm of the glass rod. The distance between the point of contact of the plant and the pivot is $\frac{1}{40}$ of the distance from the blackened glass rod to the pivot, so that any growth of the plant is magnified 40 times on the blackened rod. Thus a growth of $\frac{1}{4000}$ of an inch will be represented by $\frac{1}{25}$ of an inch on the blackened rod.

One of the features of the blackened glass rod is that a permanent record can be obtained by making a print of it on sensitized paper, from which direct measurements can be made.

A STATE BIOLOGICAL SURVEY—A SUGGESTION FOR OUR SPRING MEETING By L. M. UNDERWOOD.

THE APICAL GROWTH OF THE THALLUS OF *FUCUS VESICULOSUS*. By D. M. MOT-TIER.

SYMBIOSIS IN ORCHIDACEÆ. By M. B. THOMAS.

NOTES ON PEDIASTRUM. W. L. BRAY.

[ABSTRACT.]

Specimens of *Pediastrum* were kept under cover glass, in moist chamber, for 12 days. In this preparation was observed, in a number of cases, the breaking up and swarming of the contents of a single cell to form new colonies. From a sixteen celled specimen three cells "swarmed," each giving rise to colonies of 32 cells. Inner lamella of mother cell escapes as the enclosing membrane of swarming spores. This membrane increases in size, as did also the spores, while swarming. Spores swarmed with jerky movement about thirty minutes, gradually assuming the symmetrical and permanent position characteristic of the colony, when motion ceased. Protuberances (spines) began to appear on outer circle of cells of new colony in 12 to 20 hours. In one or two cases the enclosing membrane remained 24 hours.

Individual cells of mother colony remained undivided for twelve days, becoming several times the size of their fellows which had swarmed, very turgid and rounded as if growing independently. From another collection one case was observed where contents of a cell broke up into male swarm spores. Not able to be sufficiently observed for more definite statements.

NOTES ON THE GENUS *LYTTA*. By W. P. SHANNON.

THE GENUS *CORALLORHIZA*. By M. B. THOMAS.

NOTES ON THE FLORA OF THE CHILHOWEE AND GREAT SMOKY MOUNTAINS. By STANLEY COULTER.

THE NEED OF A LARGE LIBRARY OF REFERENCE IN CRYPTOGAMIC BOTANY IN INDIANA; WHAT THE COLLEGES ARE DOING TO SUPPLY THE DEFICIENCY. By L. M. UNDERWOOD.

BOTANICAL ASSEMBLIES IN THE UNITED STATES ANNOUNCED FOR THE YEAR 1893.**By J. C. ARTHUR.**

DEVELOPMENT OF OVULE IN ASTER AND SOLIDAGO. By G. W. MARTIN.

THE LILLY HERBARIUM AND ITS WORK. By JOHN S. WRIGHT.

The herbarium, though connected with a pharmaceutical laboratory, does not differ in essential features from that of any college, where the purpose is to do work in systematic botany. While medicinal forms are especially sought for, it is the policy of its supporters to build up a large general plant collection, and to this end collections of plants have been secured from many parts of the world, irrespective of medicinal forms which they might contain. The botanical laboratory maintained in connection with the herbarium is arranged for work in structural botany, with ample equipment for histological work, in the way of microtomes, microscopes and accessories. The laboratory and herbarium have been organized to detect adulterations and substitutions in drugs of botanic origin, and to do research work in botany as it pertains to pharmacy.

NOTES ON ROOT TUBERCLES OF INDIGENOUS AND EXOGENOUS LEGUMES IN VIRGIN SOIL OF THE NORTHWEST. By H. L. BOLLEY.

ADDITIONAL FACTS REGARDING FOREST DISTRIBUTION IN INDIANA. By STANLEY COULTER.

EVIDENCES OF MAN'S EARLY EXISTENCE IN INDIANA, FROM THE OLDEST RIVER GRAVELS ALONG THE WHITEWATER RIVER. By A. W. BUTLER.

THE CRAWFORD MOUND. By H. M. STOOPS.

NOTES ON ARCHEOLOGY IN MEXICO. By J. T. SCOVELL.

SOME EFFECTS OF MUTILATION ON THE FORMS OF LEAF AND SEX OF MORUS ALBA
AND MORUS NIGRA. By A. N. SOMERS.

ANCIENT EARTHWORKS NEAR ANDERSON, INDIANA. By FRANCIS A. WALKER.

Near Anderson, Madison county, Indiana, there is a system of earth works consisting of one large and six smaller ones, the small ones lying south and west of the large one. It is on the south half of Section 16, Township 19 north, Range 8 east, and three miles east southeast of the courthouse.

The principal work is a circular embankment with a ditch on the inside next to the embankment, with an enclosed area, and a small mound in the center of the enclosure. A gateway opens to the south 10 degrees 30 minutes west of the center of the mound, 30 feet in width, as the ditch terminates on each side of it. The work is a true circle 360 feet in diameter and 1,131 feet in circumference, with an area of 2.35 acres. The enclosed part within the ditch is 140 feet in diameter, with an area of .35 of an acre.

The ditch is 60 feet wide, and the embankment at its base 50 feet wide. The entire central area has been filled a depth of 3.2 feet, and the central mound, which is 55 feet in diameter, is 3.75 feet above the central area.

The embankment has an average height of 8.4 feet, with a variance of 3.3 feet, the same not being of uniform height, the highest point being 9.5 feet.

The average depth of the ditch is 6.92 feet, the depth not being uniform, it also varying 3.3 feet, and as compared with the central area is 10.12 feet, with a maximum depth of 11.75 feet. The average distance from the top of the embankment to the bottom of the ditch is 14.96 feet.

Of the smaller works, three are northwest, two southwest and one southeast of the large one. The principal one of these is 195 feet north 70 de-

grees 30 minutes west of the center of the large one. It is oblong and irregular in shape, the center constricted, and has an extreme length from outside to outside of 200 feet, the long diameter being at a bearing of north 56 degrees west.

There is an embankment of irregular height, not to exceed 3 feet, and a ditch within from 1 to 3 feet deep, and a small mound at the west end of the central area. It is 146 feet in diameter from outside to outside at each end of the work, and the constricted part is 142 feet in diameter. The central area is 75 feet at the east end, 85 feet at the west end, and the constricted part only 60 feet in diameter.

Northwest of this work, and 552 feet north 75 degrees 50 minutes west of the center of the large work is a circular mound, without ditch or embankment, 60 feet in diameter and about 18 inches high.

The other mound in this group of three is 64 degrees and 30 minutes west of the center of the large one, irregular in shape and outline and is hard to trace. It is almost contiguous to the embankment of the large work, and there now remains but a faint trace of the ditch and embankment.

At a point south 54 degrees 45 minutes west distant 446 feet from the center of the large work is a small one 100 feet in diameter. It is a true circle, with an embankment and ditch within, and a central area of 47 feet in diameter. There is a gateway south 66 degrees 30 minutes east, and from the top of the embankment to the bottom of the ditch it is 2½ feet. This mound is very regular and clearly defined.

South of this one 710 feet south 14 degrees 30 minutes west of the center of the main work is another small work, also 100 feet in diameter. The public road runs through this and has destroyed all but the north embankment, which is about 18 inches from the top of the embankment to the bottom of the ditch within.

Two hundred twenty-five feet south 36 degrees east of the center of the main work is another figure 33 feet in diameter, with gateways at the opposite ends. There is another embankment with a ditch within, and it is about 18 inches from the top of the embankment to the bottom of the ditch.

This group, known throughout the adjoining country as "The Mounds," is on the south bank of White River, on a bluff 75 feet in height. The point of location is the highest in this vicinity, and commands a view of the surrounding country. There is a deep ravine on the west, and one

also east of the works which is about half way between them, the ravines being one quarter of a mile apart. The large work is about 200 feet south of the brink of the river bluff, and one arm of a small ravine north of it comes up close to the west side of the principal work in the group of three. At the base of the bluff and in the east and smaller ravine there are a number of large, bold, running springs of chalybeate water. The bluff is composed of clay, sand and gravel, the sand and gravel being at the base, and out of this the water flows.

"The Mounds," as they are usually called, are in a forest of oak, beech, walnut and ash timber. Some very large trees grew on the embankments; among others, several walnut, which have been cut off. One, four feet in diameter, the stump of which is now gone, grew on the work first described, lying northwest of the large one.

The works still remain covered with a growth of timber in no respects differing from the adjoining forest.

In the bottom of the ditch on the east side of the large work there lies a granite boulder about three feet in diameter, apparently where left when the ditch was being dug.

The river and the ravines on each side afford excellent drainage, and the thick layer of leaves protect the embankment from erosion. The embankments being so heavy, the water that gathers within is not able to force its way through, and no gullies or washes have occurred; in fact, the whole system, especially the large work, is in an excellent state of preservation and seemingly as perfect as when abandoned by the Builders.

About ten years ago, the writer, in company with Dr. Joseph Tingley, then of Asbury University, made an excavation in the center of the mound in the main works. At a depth of about four feet we found a bed of ashes, charcoal, and burned bones, the bones crumbling on exposure to the atmosphere. Dr. Tingley claimed they were not human bones, but of some small animal. We found no stone or any arrangement of the earth in the form of an altar, and the fire seemed to have been there before the mound was built above it. The earth was baked and reddened by the action of the intense heat of the same. Over this the mound was then built as indicated. We dug down about two feet below this stratum, but found no further evidence of fire or any unusual arrangement of earth, nor any evidence that the same had been disturbed, further than in the construction of the central area, which had been filled as before mentioned.

Directly north of the main work on the side of the bluff, about ten feet above low water mark, is an outcropping of hard pan, under which one can enter for a short distance through an opening.

In the neighborhood of the Mounds there is a tradition that there is a cave underneath this hard pan, connected with the works. The writer has not been able to find any one who has any definite knowledge about it, and upon examination of the same himself, this opening seemed to be nothing more than a fox hole in the gravel underneath this outcropping.

These earth works have an excellent location as a pleasure resort. They are located in a forest of about 100 acres. On the north side of this forest flows White River, and on the south is the road leading from Anderson to Muncie. The Big 4 Railroad runs about a quarter of a mile south of the forest, and in the summer time there are frequently excursions from Anderson, Muncie and points along the Big 4.

The real estate on which these works are located belongs to parties who have no knowledge of their worth as pre-historic remains, and who value them solely from a commercial standpoint.

The city of Anderson has extended in this direction about one and one-half miles, and the purchase of this real estate has been in contemplation by parties who proposed converting the same into a pleasure resort, and there is a possibility, as it is located so near the city, of the grounds passing into other hands, the forest being cleared away and changes made in the original outlines, and the value of these works, as pre-historic remains, destroyed.

It is not the object to advance any theory or to speculate upon the purpose of the builders of this system of earth works, but to give data and facts as to their form, size and location, so that should anything occur by which they would be changed or destroyed, these facts might be preserved.

In addition to the measurements above given, drawings, maps and cross sections have been made and photographs taken.

The writer, with Dr. J. M. Coulter and W. S. Ellis, visited these works, and while there, Dr. Coulter suggested that such action be taken, and it was done at his suggestion.

There is a further purpose in this paper that facts may be presented to this body and an interest created, and if these works are found of sufficient importance, steps be taken, looking to their preservation. In their locality, they are looked upon simply as a curiosity, with little thought of

their real worth. A few, however, are manifesting an interest, and are ready to co-operate with this body in anything that may be done, either in the way of securing further facts or preventing their destruction.

ARCHAEOLOGY OF TIPPECANOE COUNTY. By O. J. CRAIG.

DESCRIPTION AND ELEVATION OF MOUNT ORIZABA. By J. T. SCOVELL.

THE CLIMATE AND GLACIERS OF MOUNTS ORIZABA AND POPOCATEPETL. By J. T. SCOVELL.

SOME INDIAN CAMPING SITES NEAR BROOKVILLE. By A. W. BUTLER.

REMARKABLE PREHISTORIC RELIC. By E. PLEAS.

THE BRUNS' GROUP OF MOUNDS. By H. M. STOOPS.

THE MOUNDS OF BROOKVILLE TOWNSHIP, FRANKLIN COUNTY, INDIANA. By H. M. STOOPS.

REMARKS ON ARCHAEOLOGICAL MAP MAKING. By A. W. BUTLER.

EXPLORATIONS IN WESTERN CANADA. By C. H. EIGENMANN.

[ABSTRACT.]

An account was given of explorations undertaken under the auspices of the British Museum from Winnipeg to the Pacific coast, and from Portland, Ore., eastward. The headwaters of the following rivers were crossed and their fish faunas compared: The Red River of the North, the Saskatchewan, the Columbia, the Fraser, the Missouri. About twenty per cent. of the species collected were new to science. The most interesting of these was a new genus of *Percopsida*, *Columbia* from Oregon. Several species not before taken on the Western slope were obtained. It was noticed that the number of fin rays of Pacific slope fishes was increased over their Atlantic slope relatives, or else some of the rays were modified into spines, as in the case of *Columbia* and *Meda*.

NOTES ON THE LOSS OF THE VOMERINE TEETH WITH AGE IN THE MALES OF THE SALAMANDER, *DESMOGNATHUS FUSCA*. By F. C. TEST.

THE WORK OF THE U. S. FISH COMMISSION STEAMER ALBATROSS IN THE NORTH PACIFIC AND BERING SEA IN 1892. By B. W. EVERMANN.

[ABSTRACT.]

Last winter a treaty was entered into between the governments of the United States and Great Britain, in which it was agreed to leave the various questions in dispute regarding the fur-seal fisheries to a board of arbitration, which will meet at Paris next March.

Very soon after the signing of this treaty, the State Department requested the Commissioner of Fish and Fisheries to undertake the collecting of information regarding the fur-seal of the North Pacific and Bering sea.

It was very soon arranged that the Fish Commission should undertake the work, the U. S. Fish Commission steamer, *Albatross*, then as now, on the Pacific coast, was detailed for the purpose, and it fell to my lot to be sent out as Senior Naturalist of the scientific staff of the *Albatross* to have immediate charge of the proposed investigations.

It was within the scope of the investigations to study the movements

of the seals during their return in the spring to their breeding grounds, to note the position of the herds from day to day, whether the two sexes and the younger seals all traveled together or in separate herds; we were also to determine experimentally the relative effectiveness of the different methods of killing the seal at sea, the percentage of seals lost by each method, the percentage of males, females, or young killed in indiscriminate hunting; a study was also to be made of their food and food-habits: in short, attention was to be paid to everything which would throw any light upon the natural history of this valuable animal.

I joined the *Albatross* at Port Townsend, Washington, March 27, and four days later we steamed through the Straits of Fuca and began our investigations in the North Pacific. At this time it is not proper that the details or results of the work should be given. Suffice it to say that the investigations and studies of seal-life were continued until September, and that during that time the *Albatross* was pretty well over the North Pacific and Bering Sea, and made special visits to a number of points on the mainland of Alaska as well as to numerous islands. Among the places visited may be mentioned Sitka, Prince William Sound, Cook's Inlet, Kadiak, various islands of the Aleutian chain, the Commander Islands only eighty miles off the Asiatic coast, and the Pribilof Islands, where are situated all the breeding grounds of our fur-seal, and where I spent two weeks studying the seals upon the rookeries.

The report upon the entire summer's work of the *Albatross* concerning the seal is now in the hands of the State Department, and cannot now be made public: but while carrying on this work opportunities occurred for making collections in other lines of natural history, and I was, of course, not slow in availing myself of them.

The collection of fishes is quite large, and contains a number of interesting species from Sitka, Unalaska, Atka, Attu and Bering Island.

Among these is a very fine series of the Atka mackerel, *Pleurogrammus monopterygius*, an important food-fish, hitherto but poorly represented in museums.

An important collection of birds was also made, a part of which collection-- the ptarmigan-- is treated in another paper.

Several hundred plants were collected, chiefly at Unalaska, the Pribilof Islands, and Sitka.

All these collections are now being studied, and will be reported upon in due time.

EARLY STAGES IN THE DEVELOPMENT OF CYMATOGASTER.* BY CARL H. EIGEN-MANN.

The investigation of which this is an abstract has been conducted with various intermissions since December 1888. I present here simply the result. The proof for any one of the propositions would take up more than the time allotted for all of them. The details with all necessary figures will be published during the year by the U. S. Fish Commission.

A large per cent. of the California fishes bring forth their young alive. The members of one family of these fishes, the *Scorpanida*, bring forth many thousands of young in a very immature condition. The members of the other family, the *Embiotocida*, bring forth comparatively few young, 3-80, but these are sometimes an inch or two in length and resemble the parent as much as the new born mammal resembles its parent. It is this family which is of great interest and to which I devoted most of my time. After examining many of the species just before and during gestation I selected *Cymatogaster* for a special study, because the peculiarities have become most marked in this species. The results are as follows:

1. Copulation takes place in July. This statement is based on the fact that the testes of the male are very much enlarged at this time and on the fact that the ovaries from now on are filled with spermatozoons. The act of copulation has not been observed.

2. The secondary sexual differences are considerable—among them may be mentioned a small gland or bag on either side of the anal of the male. From it extends a papilla forward to beyond the anterior margin of the fin.

3. The spermatozoa have a long rod-shaped head in place of the globular one usual in fishes.

4. The spermatozoa remain dormant in the ovary till December when they become exceedingly active.

5. The eggs mature and are fertilized between November 1st and February 1st, the largest fishes maturing the eggs earliest, the next in size a little later and the smallest individuals last.

6. Those spermatozoa not utilized in fertilization remain in the ovary for several weeks longer. They are finally eaten by the larva when the digestive tract of the latter has been sufficiently developed.

7. During the early stages of gestation the females remain in shallow

* I have hitherto referred to this fish as *Micrometrus*. A re-examination of the literature bearing on the subject proves that this name is not available.

water; males are then rarely seen. Later they become scarce but near the time the young are freed and shortly afterwards they are again found in shallow water.

8. The largest ovarian eggs measure about .3 mm. in diameter. During the process of maturation the egg contents shrink to a diameter of .2 mm. or to less than one-third of its maximum size.

9. The egg of this fish, *Cymatogaster aggregatus*, is 130 times smaller than the normal fish egg which has an average diameter of 1 mm.

10. This small size is largely if not entirely due to the non-formation of deutoplasm.

11. The egg is fertilized while still in the follicle. Some sections show the extrusion of the second polar globule and the presence of the male pronucleus in an egg still surrounded by the cells of the follicle. The latter have begun to degenerate.

12. The development begins after the egg has been freed from the follicle. Eggs with one, two, four, eight and sixteen cells as well as many later stages were found free in the ovary.

13. Neither the developing eggs nor the young are in later stages at any time connected with the parent nor is the position of these in relation to the ovarian structures a fixed one.

14. The duration of gestation is probably five months and the number of young from three to twenty according to the size of the parent. In less than a year after birth the young are with young.

15. The food of the young is supplied by the epithelium of the ovary. The cells enlarge and become clear, when they collapse, their contents are emptied into the lumen of the ovary and the framework of the cells soon follows. When the intestine begins its work the spermatozoa serve as part of the food. The ovary at no time was observed to contain more fluids than the peritoneal cavity. (In other species considerable fluid is sometimes present.) Before the development of the alimentary tract the ovarian fluid is probably appropriated by a process of intercellular digestion on the part of the epidermal cells.

16. The yolk is a waning structure and can scarcely be taken into consideration in accounting for the growth of early stages.

17. During the whole of gestation respiration is carried on by the osmotic action between the general surface and the closely applied ovarian structures. When the alimentary tract is opened a current is kept flowing through it and aeration is, in all probability, effected by the ali-

mentary tract. In later stages the fins become highly vascular and doubtless serve both for purposes of aeration and food absorption.

18. There is present in the entodermic pole of the developing egg a body the like of which has not been observed in any other egg. It consists of a mass of protoplasm imbedded in the yolk. It is dissolved near the time of the closing of the blastopore. Mr. J. W. Hubbard, one of my students, has connected its history with that of the yolk nucleus which is a conspicuous structure in the ovaries of adult fishes in egg from 20 μ up to maturity. It is a general extrusion from the nucleus of the young ovum and probably represents the histogenetic or somatic portion of the nucleus and this in part at least corresponds to the macronucleus of ciliate infusoria.

19. Before segmentation begins the whole of the germ is separated from the deutoplasm. The first cleavage plane extends entirely through the germ to the yolk before the second cleavage begins.

20. A segmentation cavity is not formed during segmentation but appears later by a separation of the ectoderm and entoderm.

21. The third cleavage plane is not parallel with the first as is usual in fishes, but is semi-equatorial. This has nothing to do with the horizontal cleavage claimed to have been seen by Hoffman and by Brook. It is taken to be a pseudoreversion to primitive methods of segmentation with the reservation that this condition is not perfectly homologous with the third segmentation of the frog or *Branchiostoma*, and would not be had the yolk entirely disappeared.

22. The periblast is formed from a few of the marginal cells. Like the yolk it is a waning structure. Only about 12 cells are ever formed. They take no part whatever in the formation of the embryo. All of them persist as long as a trace of the yolk is left. It, with the final part of the yolk, is absorbed by the blood of the sinus venosus. The liver has nothing to do with its final absorption as Wilson has claimed but simply mechanically encloses the nuclei above and behind.

23. During an early stage of segmentation some of the marginal cells of the blastoderm creep over the yolk till they nearly if not entirely cover it.

24. Before gastrulation the yolk sinks into the mass of the blastoderm the cells of which re-arrange themselves about it and nearly enclose it.

25. The gastrula is finally formed by a process of delamination of en-

toderm from ectoderm and is completely diplastic and symmetrical, the blastopore closing at the entodermic pole of the egg.

26. Before any other organs become evident the sex cells become conspicuous. Their fate I have discussed elsewhere.

27. The earliest stages of the formation of the embryo have not been clearly made out with the material at hand. It is, however, certain that in one of the figures published by me in the "Journal of Morphology," I mistook the tail for the head. The conditions are extremely similar to those found in the mammalian embryos, except that the central cavity is filled with yolk instead of fluid.

28. The mesoderm is formed by a process of delamination from the entoderm. It is formed as two sheets and over the whole of the entoderm exclusive of the axial line.

29. The young fish is freed from its membrane in a very immature condition. It completely encircles the yolk; in fact the head and the tail overlap. It is incapable of motion at this time and indeed the cells which will form the muscles have scarcely become differentiated. The hatching process is due to the growth of the embryo and not to its activity as is usually the case. The fin folds do not appear till much later.

30. Kupffer's vesicle appears very early and is very large. It consists when fully formed of a dome-shaped roof over a large cavity surrounded on the sides by entoderm. It at first rests on the yolk but soon the yolk is forced down and presents a deep impression just beneath the vesicle. Later the vesicle is divided into three distinct cavities. The upper dome-shaped portion persists for some time and probably represents part of the neurenteric canal. The middle portion remains for some time as an enlarged part of the intestine. The lowest portion is the cavity formed in the yolk. It has acquired a roof by the ingrowth of the entoderm cells to form the floor of the intestine. This cavity usually remains for a considerable time.

31. The entoderm at first extends over the entire yolk. It later becomes restricted to a comparatively narrow strip along the axial line.

32. The floor of the alimentary canal is formed by the ingrowth below of the marginal cells of the entoderm. The ingrowth progresses from in front back. A lumen is not formed at once. The lumen is formed in the hind gut and in the gill region at the same time and gives abundant evidence that the alimentary tract is bilateral. The middle anterior part remains a solid mass of cells after the lumen has appeared both in front and behind this tract.

33. The anterior opening of the alimentary canal to the exterior is through the gill slit in larvæ 1 mm. in length, *i. e.* long before the mouth is formed. The first food enters through this gill slit. The food current before the fish can swallow is kept up by a very highly ciliated gullet which extends from behind the gill region to near the hind gut.

34. The mouth does not appear till the larva has increased 3 mm., *i. e.* to a length of about 4 mm., and during all this time the hyobranchial gill slit functions as mouth. There is here found a condition similar to the one supposed by Dohrn to explain the replacement of the annelid mouth by a gill mouth.

35. Just in front of the notochord and near the region of the hyobranchial slit a strand of hypoblast cells extends up from the median portion of the alimentary tract to above the notochord. This strand of hypoblast cells lies in the region where Dohrn supposes the annelid œsophagus to have disappeared.

36. The hind gut soon becomes enormously enlarged and later a large number of long villi are developed.

37. The larvæ retain as an ancestral trait a large yolk sack, the yolk being quite minute. The sack is largely taken up by the large pericardium through which the long tubular heart extends from below and behind, upward and forward.

38. In conclusion: The fish in almost all its stages has become highly specialized. Many stages resemble very closely primitive conditions but the conditions can probably in but few cases be looked upon as a simple reversion. Its development has, on the other hand, become extremely ichthyized and its egg stands at the end of the chain of eggs in which the *Branchiostoma* egg, the *Elasmobranch* egg and the *normal fish* egg form links.

ON BIRDS IN WESTERN TEXAS AND SOUTHERN NEW MEXICO. By A. W. BUTLER.

SOME REMARKS REGARDING THE EMBRYOLOGY OF AMPHICOMA. By O. P. HAY.

THE CONTENT AGAINST INFECTION. By THEODORE POTTER. Published in The Cincinnati Lancet Clinic, Aug. 6, '92.

SOME STRUCTURAL PECULIARITIES OF PACIFIC SLOPE FISHES. By A. B. ULREY.

THE YOLK NUCLEUS. By J. W. HUBBARD.

PECULIAR DEATH OF AN ORIOLE. By T. B. REDDING.

THE RANGE OF THE CROSSBILL IN THE OHIO VALLEY, WITH NOTES ON THEIR UNUSUAL OCCURRENCE IN SUMMER. By A. W. BUTLER.

In 1838 Dr. Kirtland had not met with the American Crossbill (*Larus curvirostra minor*) in Ohio and Indiana. Dr. Haymond omitted it from his "Birds of Southeastern Indiana" in 1856. Dr. Wheaton reported it from Ohio in the winter of 1859-60. Evidently it was quite well known to Dr. Haymond in 1869. The winter of 1868-9 they were very abundant in the vicinity of Cincinnati. (Charles Dury.) This was doubtless the case at other places also. The range of the species at this time was supposed to be northern North America, south in the Appalachian mountains into Pennsylvania, extending in winter, irregularly over much of the United States. A letter from Mr. C. E. Aikin, of Salt Lake City, Utah, informs me that this species became very abundant in the city of Chicago in July and August 1869, and remained until late in the fall. They fed greedily upon seeds of sunflowers and were so sluggish that one could approach within a few feet of them so that they fell an easy prey to boys with catapults. In the latter part of August of the same year, he found them common in Lake county, Indiana. He also notes that they were not rare the succeeding year in the vicinity of Chicago. Dr. F. W. Langdon notes the capture of a single specimen from a flock of six or eight at Madisonville, near Cincinnati, O., Nov. 30, 1874. In the winter of 1874-5 Mr. Eugene P.

Bicknell noted these birds were present in the lower Hudson valley, and in April of the latter year found their nest. In the same article is noticed the occurrence of the species about New York City in late spring and early summer: on Long Island in midsummer, and on the Bermudas from March to May. (Bull. Nutt. Orn. Club, Vol. V., pp. 7-11.) Mr. E. W. Nelson in his paper on "Birds of Northeastern Illinois," read before the Essex Institute, December 4, 1876, says it was "formerly a common winter resident; now rare." Messrs. Dury and Freeman (Journ. Cin. Soc. Nat. Hist., 1879, p. 4), note its occurrence at Westwood, O., in 1879. Dr. J. M. Wheaton (Bull. Nutt. Orn. Club, 1879, p. 62) gives the following account of the occurrence of the species in Ohio: "On the 18th of June last, Mr. Charles Hinman killed one of these birds out of a flock of eight or ten which visited the coniferous trees in his garden in this city (Columbus). The specimen, which came into my possession by the kindness of Mr. Oliver Davie, was a male, not in full plumage. I have since learned that the Red Crossbill has remained during the season in the vicinity of Cleveland in considerable numbers, and is reported to have nested there." In commenting on this note (Ohio Geol. Survey, Vol. IV., Zoology and Botany, p. 317), Dr. Wheaton says: "I was unable to learn whether its nest had been actually discovered," and adds: "It has been known to nest in Indiana within a few years." I regret very much that I have been unable to get any clue whatever to the authority upon which this statement is made. Prof. A. J. Cook in writing of the Birds of Michigan says of the American Crossbill: "Occasional in summer. Dr. H. A. Atkins took nests of this species at Locke, July 13, 1880." It had previously been reported as breeding in Minnesota. In July and August, 1880, they were noted at Rugby, Tenn. (The Oologist, Vol. V., pp. 78-9; Bull. Nutt. Orn. Club, Vol. VI., pp. 56-7.) Dr. C. Hart Merriam notes it as an "abundant resident" in the Adirondack region. He says it is "rather scarce and irregular in summer, but the commonest bird in winter and early spring. Breeds in February and March while the snow is still four or five feet deep on the level and the temperature below zero (Fahr.). Have taken full fledged young in April." (Bull. Nutt. Orn. Club, Vol. VI., p. 229.)

Mr. C. W. Beckham (Birds of Nelson County, Kentucky; Ky. Geol. Surv., p. 24), says: "A flock of six or eight of these birds appeared here on November 18, 1882 on some pine trees, the first time I had ever observed them. They remained only a day or two, and none were seen until the 17th of March following, when I shot eight out of a flock of about twenty,

in the same place where they had previously been seen. Several flocks were observed about the same time near Bloomfield and Glenville in this county, and excited considerable comment on account of their queer bills. The weather at the time was quite mild, so that their appearance here was probably due to some other cause."

The winter of 1882-3 they were unusually abundant in many localities between the great lakes and the Ohio river. Prof. B. W. Evermann first observed them at Bloomington, Indiana, February 10, 1893. This was the second record for the state. For some time after they were common in Monroe county. March 15, 1883, Mr. E. R. Quick reported having seen a single specimen near Brookville, Indiana. April 2, my attention was attracted to a peculiar crackling sound which came from among the pine trees in my yard at Brookville. Close investigation revealed the fact that the cause was a lot of Crossbills. They were shelling the seeds out of the pine cones and the breaking of the cone scales made the sound which attracted my attention. I observed others were upon the ground feeding upon the seeds of the fallen cones. April 3 I saw six more in my yard. April 4 I saw one in a flock of Pine Finches. April 5 Mr. Quick noted one. Of those observed but one was in the red plumage. Prof. B. W. Evermann saw a few at Delphi, Carroll County, Indiana, the middle of March, 1883. At the same place about twelve were seen December 26, 1884. Mr. J. W. Byrkit informs me that they were very abundant at Michigan City, Ind., in the winter of 1883-4. Miss H. E. Colfax, in her report of the bird noted at the light house, at the same place, gives it January 16, 1884. In the winter of 1883-4 Prof. Evermann reported them very common in Monroe County, Ind. The Ornithologist and Oologist, Vol. VIII., p. 68, contains an account by A. H. Helme of their breeding April 10, 1883, near Miller's Point, L. I. Mr. Robert Ridgway (The Auk. Vol. I., p. 292), notes the probable breeding of the Red Crossbill in central Maryland in May, 1884. Mr. F. C. Brown reported their breeding in Eastern Massachusetts in the summer of 1884 (The Auk., Vol. II., p. 105). In the winter of 1884-5 they were tolerably common in Monroe county, Ind. (W. S. Blatchley, Hoosier Naturalist, 1886, p. 170). The late Mr. C. H. Bollman noted them "quite common," in the same county through March, April and early May 1885. He saw them first March 2, and last observed them May 12. Mr. J. W. Byrkit informed me that he saw the first Crossbills for the year March 24, 1885. He adds: "I am not quite positive but think the Crossbill breeds here (Michigan City), as they make their appearance about this

time and leave for the north about the middle of May." Mr. Charles Dury informed me they were abundant at Michigan City, Ind., one winter, which he thinks was 1885. He also reported Pine Finches and Redpolls from the same locality the same year. Prof. B. W. Evermann reported it from Carroll County, Ind., March 27, 1885. I am indebted to Mr. E. M. Kindle for the information that Mr. Sam Hunter reported a pair of American Crossbills to have bred at Bloomington, Ind. in 1885. Mr. Hunter informed him they nested in a pine tree and that the nest was made exclusively of pine burrs. Mr. R. R. Moffitt informs me that Red Crossbills were taken in Tippecanoe County, Ind., in 1885. He says they nested there. Prof. B. W. Evermann noted them at Camden, Ind., March 27 and April 13, 1885, also a large flock at Burlington, Ind., April 23, 1885.

Mr. Wm. Brester reported its occurrence in the mountains of Western North Carolina in the summer of 1885 (*The Auk.*, Vol. III., p. 107) and says: "Seen only on the Black Mountains where it was numerous in small flocks throughout the balsam forests above 5,000 feet. At Highlands I was told that it regularly appeared in winter about the outskirts of the town." Mr. Charles W. Richmond (*The Auk.*, Vol. V., p. 22), gives upon the authority of Mr. Hugh M. Smith, the information that an adult male American Crossbill, accompanied by a young bird, was seen May 17, 1885, within the District of Columbia. Prof. L. L. Dyche reports the occurrence, in the winter of 1885-6 of the Western Red Crossbill, *Loxia curvirostra stricklandi*, at Lawrence, Emporia, Manhattan and Wakarusa, Kan. They were first observed November 1, 1885, and were last seen January 26, 1886 (*The Auk.*, Vol. III., pp. 258-261). The following winter I was fortunate in securing, through the kindness of Mr. A. O. Garrett, a series of specimens of *Loxia curvirostra minor* from Lawrence, Kan. March 13 and 14, 1887, he obtained four which he sent me, and later he sent me nine others which were taken March 24 and 25. The meeting of the range of these two forms is of considerable interest. Prof. B. W. Evermann reports a crossbill, species not determined, from Bloomington, Ind., February 23, 1886, and another March 8, 1886. The same authority states the late Mr. C. H. Bollman found a few specimens of the Red Crossbill near Bloomington, Ind., July 10, 13 and 14, 1886. Mr. Arthur P. Chadbourn says, in the summer of 1886 it was found in the White Mountains, N. H. (*The Auk.*, Vol. IV., p. 105). Mr. George B. Sennett, in the same volume, p. 242, gives an account of finding this species in

the mountains on the borders of North Carolina and Tennessee in July and August 1886. Mr. Arthur T. Wayne, in the same volume, pp. 287-289, notes their abundance near Yemassee, S. C., in November and December, 1886, and in January and February, 1887. He noted them again in the same vicinity November 20, 1887 (*The Auk.*, Vol. V., p. 115), also during January, 1888 (*Ibid.*, p. 208). Mr. Frank M. Chapman also reports them from Aiken, S. C., November 12, 1887, (*Ibid.*, p. 324). Mr. G. G. Williamson observed them in Monroe County, Ind., January 18 and February 6, 1886. Mr. J. G. Parker reports them from Lake County, Ind., in May, 1887. In the fall of 1887, I again observed them at Brookville, Ind. They came to feed among the pines in my yard. October 29 several were seen and they last appeared November 19. Prof. Walter Faxon and Dr. J. A. Allen give it as common in the White Mountains, N. H., in July 1874, June 1885 and June 1886 (*The Auk.*, Vol. V., p. 152.) Dr. J. A. Allen on the next page of the same number of "*The Auk*," speaks of a pair of American Crossbills taken at Mandeville, La., March 27, 1888. Prof. B. W. Evermann found them in Vigo County, Indiana in the spring of 1888. They were first seen February 6 and disappeared May 6. Mr. J. O. Snyder found them at Waterloo, Ind., March 13 and 17, 1888. Mr. H. N. McCoy informs me they were quite common in Wayne county, Ind., in the early part of 1888. They were last seen April 5. Mr. G. G. Williamson saw six or eight individuals near Muncie, Ind., April 17, 1888. May 4 he saw three others. Mr. Otho C. Poling notes their occurrence in Adams county, Ill. He gives no account of their occurrence in summer (*The Auk.*, Vol. VII., p. 239). Mr. John A. Balmer, informs me these Crossbills were found in the vicinity of Vincennes, Ind. in the winter of 1888-9. Mr. J. F. Clearwaters told me of the capture of two of these birds in Putnam county, Ind., in the winter of 1888. A flock of American Crossbills was seen by Mr. J. O. Snyder at Waterloo, Ind., April 27, 1889. Mr. Stewart E. White informs me he found them common on Mackinack Island, Mich., August 3 to August 9, 1889. Mr. H. W. McBride wrote me of taking three specimens at Waterloo, Ind., April 2, 1890. February 14, 1891. Mr. Stewart E. White saw six at Grand Rapids, Mich. He next noted the species March 16. He says it is quite rare in that vicinity. Mr. J. F. Clearwaters gave me the following account of their occurrence in Putnam county, Ind.: "On July 27, 1891, Jesse Earll was down beside the old mill pond, where we collect all our water birds, and noticed five birds on the ground, apparently probing in the mud with their bills. As they

rose he shot one which proved to be a male Red Crossbill in breeding plumage. He preserved the skin and still has it. The others were females or young, as he says none of them had any red on them."

Mr. Jonathan Dwight reported the American Crossbill on North Mountain, Penn., in June, 1891. (*The Auk*. Vol. IX., p. 137.) Dr. B. H. Warren, in his admirable "Report on the Birds of Pennsylvania," p. 228, gives it as breeding in the counties of Clinton, Clearfield, Luzerne, Lycoming and Cameron in that state.

March 1, 1892, Messrs. A. B. Ulrey and E. M. Kindle report seeing six in Monroe county, Ind. Mr. G. G. Williamson noted six near Muncie, Ind., April 16, 1892, and another April 24. Messrs. Charles D. and Lewis A. Test have kindly sent me the following interesting notes from the observations of the spring of 1892. The notes were taken near Lafayette, Ind. March 8, 1892, they saw the first American Crossbill. They were seen on the following succeeding dates: March 11; April 15, 19, 23 and 30; May 1, 3, 6, 8, 18, 20, 21, 27 and 30; June 2, 6, 22, 23, 27 and 30. The birds were seen in pine trees and also in yards and along the road. Search was made for nests but none were found. I am indebted to Mr. Otto Widmann for some valuable notes relating to the American Crossbill in Missouri last winter and spring and summer (1891-2). He says: "I never suspected these cone loving nomads to descend into a country so flat and uninteresting as St. Louis county, Mo., where nature never rears a cone without the help of the gardener. Thousands of young evergreens, especially Norway Spruces, have been planted during the past decade, but old cone-bearing conifers are few and far between. There are on my place, besides a few Norway Spruces, eighteen pine trees about thirty years old. Half of them are Austrian pines, the rest White and Scotch pines. Coniferous trees do not bear fruit every year, but last winter the Austrian pines were full of cones, getting ready to drop the seeds in early spring. Besides the maturing pine seeds our section had another attraction for erratic fruit eaters in the orchards. The apple trees had yielded an enormous crop and the demand not being sufficiently great to gather them in time, thousands of apples were still hanging in the trees when the Crossbills appeared on the scene. It was in the orchard that they made their appearance on November 13—the day after the first 'blizzard' had visited the upper Missouri valley. From this day on, the Crossbills remained in the neighborhood until the end of the month but none were here in December and January—at least I did not notice any until they began to

visit my pine trees in February. They were daily visitors all through March and until the 17th of April. From that day until May 8th none were seen, but from the 8th to the 14th they were again daily callers. After this date they were noticed twice; a party of six on June 5th, and two birds a male and female, in one of my pines on July 21st. I looked for their nest in the tree but, unfortunately it was not there! I think now that I have met with the species on several occasions in former years but did not know them. Frequenters of private gardens they were only seen when on wing or distant tree tops, and evaded identification. With us it is a shy and restless bird, easily alarmed and flying a great distance. Before taking wing and while in the air they are quite noisy with a note closely resembling the parent call of *Progne*; but when feeding in a pine tree the whole troop keeps perfectly silent, and nothing is heard but the noise made by breaking the cone scales. When present in May they are also feeding in elms." Mr. W. S. Blatchley gives me the following notes: "While sitting on the porch of a farm house in Putnam county, Indiana, July 11, 1892, I saw a single Crossbill, *Loxia curvirostra minor*, alight in the top of a pine tree in the yard and begin searching the cones for seeds. I watched it for almost ten minutes and then, that there might be no possibility of mistake in the identification, procured a gun and shot it. It proved to be a young male. On July 15 another young male, *i. e.* a male presumably of the previous year's hatching, was secured from the same tree and kept in confinement for several days, but was finally allowed its liberty."

The American Crossbills have, as has been shown, been noted within the region between the great lakes and the Ohio river in the following winters: 1868-9; 1869-70; 1874-5; 1882-3; 1883-4; 1884-5; 1885-6; 1887-8; 1888-9; 1889-90; 1890-91; 1891-2. From 1882 to 1892 they were only absent one year; 1886-7. In the winters of 1882-3, 1884-5, 1887-8 the area of dispersal was wide and the birds seem to have been generally distributed. Other years as 1868-9, 1869-70, 1883-4, they appeared, or at least were observed, in but few localities but where noted they were abundant.

The results of the inquiries concerning its summer range, particularly with relation to the Ohio valley and the territory adjacent thereto, have been wholly unexpected. Summing up the occurrence in summer and the evidence of its breeding in the region last referred to we note as follows: In the summer of 1869 they were abundant in the vicinity of

Chicago, both in Illinois and Indiana. In the summer of 1878 they were found at Columbus, O., and abundantly at Cleveland, where it was reported to have bred. Dr. Wheaton refers to their having nested in Indiana as a fact well known to him. Dr. H. A. Atkins is said to have taken nests of this species near Locke, Michigan, in 1880. The spring of 1885 they were common at Michigan City, Ind., and Mr. Byrkit thought they might have nested. In the summer of 1885 they were reported to have nested in Tippecanoe county, Ind. The same summer they are reported to have nested at Bloomington, Ind. They were reported from Monroe county, Ind., three different dates in July 1886. They were reported from Putnam county, Ind., in the summers of 1891 and 1892. They remained throughout a part of the summer of 1892 at Lafayette, Ind. They remained even later at Old Orchard, Mo., in 1892.

These notes but serve to bring more clearly to mind the peculiar, erratic character of the bird, of which we have known, to some degree, before. The notes would also seem to indicate that much of our lack of data is due to the scarcity of observers in years past. A few years ago the collection of data regarding almost any species of bird from Indiana, or almost any other state, would have been impossible. It is not improbable, could we begin with the abundance of Crossbills at Cincinnati in 1868-9, with a number of intelligent observers equal to that available now, we could have a collection of observations covering its whole range between the Ohio river and the lakes and perhaps including its movements for almost every year. Those blank years do not necessarily signify that it was wanting in the territory studied, but that for some one of a great many reasons, it was not observed. The erratic distribution of the species applies as well to its summer range as to that in winter. It seems very probable that the species breeds to some extent throughout the Ohio Valley. It is true that no specimens representing either the nest or eggs have been, so far as I know, preserved. Yet the evidence presented indicates that the breeding range of the species in the United States is not confined to the coniferous forests of the mountain ranges.

Loxia leucoptera, WHITE-WINGED CROSSBILL. This species is not met with in the Ohio valley so often as the last mentioned form. Its range lies farther to the northward. Its distribution within the United States, both in winter and summer, is much less extensive than is that of the American Crossbill. Audubon mentions its breeding in Pennsylvania in summer, but this is probably an exceptional case. Dr. J. M. Wheaton gave

it in his catalogue of Birds of Ohio, in 1861. Mr. Charles Dury found them abundant in the vicinity of Cincinnati, O., in the winter of 1868-9, in company with the last mentioned species. He says, "they were in large flocks containing both species in the proportion of two of the former to one of the latter" (the present) "species." Mr. C. E. Aiken informs me that this species was in company with the American Crossbill when they were so common in the vicinity of Chicago in the summer of 1869. He also noted them in Lake county, Ind., the latter part of August of that year. He says they displayed the same habits as the preceding species. His recollection is that the White winged form was less abundant, a little later in their arrival, and more wary. They remained through the winter. Prof. A. J. Cook informs me that one was killed by Dr. H. A. Atkins, at Locke, Mich., Aug. 9, 1875. A pair of White-winged Crossbills were taken at Fort Wayne, Ind., about 1878. The female is now in the collection of Mr. C. A. Stockbridge of that city. Mr. W. L. Scott notes the occurrence of a flock of White-winged Crossbills near Ottawa, Canada, towards the latter part of June 1882 (*The Auk.*, Vol. I., p. 159). Mr. Fletcher M. Noe notes the occurrence of this species near Indianapolis, Ind., in the early part of 1883. February 6, 1883, Prof. B. W. Evermann shot two males from a flock of fifteen of these birds in a yard at Bloomington, Ind. February 10 he secured a female, and a few days later, two other specimens near the same place. Miss H. E. Colfax reports it from Michigan City, Ind., June 26, 1884. Mr. J. W. Byrkit found both species together in large flocks near Michigan City, Ind., the winter of 1883-4. Mr. Charles Dury reports it from Michigan City, Ind., he thinks in 1885. Faxon and Allen report seeing a few in the White Mountains, N. H., June 1886. (*The Auk.*, Vol. V., p. 152.) Hon. R. Wes McBride has noted it as a winter visitor in DeKalb county, Ind. Dr. C. Hart Merriam gives it as a resident in the Adirondack region but adds, comparing it with the American Crossbill, "not nearly so common as the last." (*Bull. Nutt. Orn. Club*, Vol. VI., p. 229). Prof. B. W. Evermann informs me that he saw one in his brother's yard at Burlington, Ind. He says, "after watching it for a while I struck it with a stick, killing it." March 16 he saw another specimen of this species at Camden, Ind.

The only instance I know of its occurring in the Ohio valley in summer is that given by the late Mr. C. H. Bollman. He wrote me that he saw eleven on a fir tree in Bloomington, Ind., June 24th, 1886. A few days later he several times noted specimens of the other species.

Everywhere in the Ohio valley this species seems to be quite rare and exceedingly irregular in its occurrence. Mr. E. W. Nelson and Mr. Otto Poling note it as much less common in Illinois than formerly. With the exception of the winter of 1868-9 and the succeeding summer I do not know of its having appeared in any considerable numbers in any of the tier of states just north of the Ohio river.

NOTICE OF A TERRAPIN TO BE RESTORED TO THE FAUNA OF INDIANA. By O. P. HAY.

A MIGRATION OF BIRDS AND ONE OF INSECTS. By T. B. REDDING.

THE SOUTH AMERICAN CAT FISHES BELONGING TO CORNELL UNIVERSITY. By E. M. KINDLE.

[ABSTRACT.]

Some years ago, the late Charles Frederick Hartt made a collection of fishes in South America, which he gave to Cornell University. This collection had never been studied until last spring, when it was sent to Dr. Eigenmann. The cat fishes in it were turned over to me to identify. In the identification of these I have used Dr. and Mrs. Eigenmann's "Revision of the South American Nematognathi." I have also had the use of Dr. Eigenmann's private library, which contains nearly all of the published literature on South American fishes. In the identification of doubtful species I have had the assistance of Dr. Eigenmann.

The collection contains nineteen genera and twenty-seven species, distributed among the three families, Loricariidae, Siluridae, and Callichthyidae, and their sub-families.

Two new species have been found in the collection. One of these belongs to the genus *Hassar*. The name *wilderi* is proposed for it in honor of Prof. Wilder, of Cornell University. It is represented by four specimens from the Tocantins river. The other new species belongs to the genus *Hemiancistrus*, all of whose species are apparently rare. It has been named *longipinnis* in reference to the long dorsal.

The collection is mainly from the Amazon and the LaPlata, and their tributaries. The waters of the Amazon, the LaPlata, and the Orinoco are united through their tributaries, and so far as their fish fauna is concerned form but one river system. The fish fauna of any one of these rivers is therefore very similar to that of the others. The only genus which was considered peculiar to the LaPlata fauna is *Cochliodon*. This genus I find represented in the collection by four specimens from Marajo, near the mouth of the Amazon; so there is now no genus from the LaPlata which is not also found in the Amazon's system. These specimens, which belong to the species *Cochliodon cochliodon*, are of further interest inasmuch as the genus and species has heretofore been known only from the types in the Museum of Vienna.

From the Rio San Francisco there are but four specimens, all of a species common to the mouths of the east coast rivers of Brazil. The rivers of southeast Brazil, which Dr. Eigenmann has shown to have a fish fauna distinct from that of the Amazon to the north and the LaPlata to the south, are not represented in the collection. Lake Titicaca is represented by a single specimen, *Pygidium rivulatum*. This species, with *Rhamdia quelen*, are the only cat fishes found in Lake Titicaca. Both of these are alpine forms characteristic of the mountain streams of the Peruvian Andes.

HOW THE COLLEGES COULD AID THE PUBLIC SCHOOLS IN TEACHING BIOLOGICAL SUBJECTS. By W. W. NORMAN.

THE ICHTHYOLOGIC FEATURES OF THE BLACK HILLS REGION.* By B. W. EVERMANN.

ABSTRACT.

Last September I was directed by the U. S. Commissioner of Fish and Fisheries to make certain investigations in Iowa, Nebraska, South Dakota and Wyoming for the purpose of determining the advisability of establishing one or more fish-cultural stations in those states, and if it should be found desirable to establish stations in that region, to determine the most suitable places for their location.

Investigations of this kind require a more or less careful study of the

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physical, chemical and biological features of the streams and lakes of the region under consideration, for these in their various phases are the forces or conditions which constitute the *fish-environment*, and which determine the abundance, condition and distribution of the fish life of each hydrographic basin.

While carrying on these investigations, I spent the greater part of the month of October in and about the Black Hills, and it is to some of the biologic characteristics of that region that I desire to call your attention.

The Black Hills are, as you are aware, an isolated mountain group lying in southwestern South Dakota and eastern Wyoming. These Hills lie wholly within the basin of the Cheyenne River, which is formed by the union of the North and South Forks. The North Fork of the Cheyenne, or the Belle Fourche, as it is usually called, has its rise west of the Hills, flows around them on the north side, and to the eastward joins the South Fork which also rises west of the Hills and sweeps around them to the southward in a wide curve very much like that of the Belle Fourche on the north.

The immediate drainage of the Hills is by means of numerous smaller streams, nearly all of which flow eastward in approximately parallel courses to one or the other of the two Forks, those flowing into the Belle Fourche doing so from the right bank, while those reaching the South Fork flow into it from the left bank. During our stay in this region we made collections of fishes in the following streams: Middle, Sand, Red-water, Crow, Chicken, Spearfish, Whitewood, Beaver, Rapid, Elk, Fall, Warm, Cold, Minnekahta, and Cottonwood creeks, the Belle Fourche and the South Fork of the Cheyenne, and in Montana and Cox's lakes, nearly all of which are well supplied with certain species of fishes. The study of these collections has opened up a number of interesting questions in geographic distribution.

The fish fauna of that portion of the Missouri system lying in and about the Black Hills is peculiarly restricted in its character. The fifteen species contained in this collection,—and no other species has ever been reported from any definite locality of this region,—represent but four families, viz.: two catfishes, four suckers, eight minnows, and one member of the codfish family. Eight of the fifteen species belong to one family, the *Cyprinidae*. Not a single species of spiny-rayed fish has been found in the streams about the Hills, and it is not likely that any will be found there. Many of the streams in or near the Hills would apparently furn-

ish congenial homes for sunfishes, bass, and even several species of darters. That these are not there must be due to the nature of the lower courses of the streams draining the hills, and that of the Cheyenne, to which they are all tributary. The Cheyenne is ordinarily a shallow stream whose waters are always more or less alkaline and filled with solid matter in suspension from the extremely easily eroded country through which it flows. The lower courses of the streams flowing from the Hills are through the same Cretaceous beds and partake of the same character. Only those species with which the struggle has become most severe will be driven to seek protection and food in the muddy, alkaline streams, and they alone would eventually find their way into the purer, clearer waters above. This, of course, means the soft-rayed, non-rapacious fishes, the suckers and minnows and other mud-loving forms.

The spiny-rayed species are aggressive, extending their attacks to all weaker forms about them, while the soft-rayed species are defensive, and seek protection in retreat. A spiny rayed fish has no occasion to ascend into the muddy, alkaline and uncongenial portions of these streams; the only thing which would cause him to do so would be a quest for food, but he finds it easier and more agreeable to get food of sufficient quantity and quality where he is. Not so with the soft-rayed fish; he must not only search for suitable food, but he must also see that his enemy, the spiny-rayed fish, does not catch him. The attacks of his enemies were probably the first cause impelling him to take refuge in the turbid water. Finding suitable and sufficient food in this new environment, and total relief from the persecutions of his old enemies, he finds the struggle for existence easy, the surroundings in time become bearable and perhaps agreeable, he moves about at will through all parts of the muddy stream and even into the headwaters where, still finding an abundant food supply and none of his old enemies, he is content to make his home.

Before mining began in the Hills in 1875 and 1876, nearly every stream possessed all the natural conditions necessary to make it an excellent trout stream. The waters were clear and cold, not subject to contamination from any source, and suitable food, such as insects and insect larvae, and the smaller crustacea and mollusca, was undoubtedly found then, as now, in abundance. With the exception of a few streams which are now ruined by mining operations, the creeks of this region are yet excellent for trout.

The explanation for their absence is practically the same as that which

accounts for the absence of spiny-rayed fishes. Land barriers have evidently proved competent to prevent trout getting in from the headwaters of the trout streams to the westward, and the mud and alkali which they encountered in the lower portion of the Yellowstone, the Missouri and the Big Cheyenne have as certainly proved an impassable barrier from that direction. Among the many regions of the United States which possess the necessary natural conditions for trout, the Black Hills district is the only one of any considerable area, if we except portions of the Yellowstone National Park, in which one or more species of *Salmonidae* are not or have not been indigenous. The absence of trout and all other species of fish from the various lakes and streams of the Yellowstone National Park (*e. g.* Lewis and Shoshone lakes, Gibbon, Firehole and Little Firehole rivers, and Indian, Glen, Nez Percé and Sentinel creeks) is undoubtedly accounted for by the presence of impassable falls where these waters leave the great rhyolite sheet which covers the Park, as shown by the investigations made by Dr. Jordan in 1889. The presence of trout in Yellowstone Lake and tributary streams, notwithstanding the fact that the outlet of Yellowstone lake (Yellowstone River) has two enormous falls which wholly prevent the ascent of fish, is quite evidently due to the most interesting and curious fact that there is a continuous waterway furnishing easy passage for trout from the upper tributaries of Snake River, by way of Two-Ocean Pass, into the upper Yellowstone River. That Yellowstone Lake could have been, and almost certainly was, stocked in this way from the Columbia basin, was demonstrated by the investigations which I made during my visit to Two-Ocean Pass in August, 1891.

The presence of trout in the upper tributaries of the Colorado, Rio Grande, Arkansas, and Platte, whose lower courses are, in some cases at least, not unlike those of the Cheyenne and Missouri, is a matter whose explanation is not without some difficulties. The relationships of the various species or sub-species of *Salmo* found in these different basins are very close and indicate a common origin at no remote date. Whether they are all descended from a form which came up from the Pacific coast or one from the Atlantic cannot be certainly known, though the bulk of the evidence points to the former view. But whatever may have been the fact, it is certain that the headwaters of the Columbia, Colorado, Rio Grande, Arkansas, and Platte have been connected in some way at some time or other, thus permitting the trout to spread into these various basins. That there are no trout in the Cheyenne basin would seem to indicate that

the streams of this system became separated and differentiated as a distinct drainage system earlier than did those of the Platte, Arkansas, Rio Grande, Colorado, or Columbia, or else that they are streams of more recent origin and have never been connected at any time with any of the streams containing trout. Such a history as this for the Cheyenne, together with the shallow, muddy, alkaline character of its lower portion, seems to be a reasonable explanation of the absence of trout from the Black Hills.*

The effect of the peculiar alkali water of the Cheyenne and the lower course of the streams flowing from the Black Hills has been to reduce the fishes to a nearly uniform pale, faded or bleached appearance. Except those found above the alkali water, they are almost wholly without pigment cells of any kind. Perhaps the most extreme case of bleaching is that of the flat-headed minnow, *Platygobio gracilis*, which, of all American fishes, seems to be the one most perfectly adapted to these alkali streams.

The following is a list of the species of fishes obtained in the Black Hills and vicinity:

SILURIDÆ, OR CATFISHES.

1. *Noturus flarus* Rafinesque. Yellow Cat. South Fork of Cheyenne River at Cheyenne Falls, and Belle Fourche River at Belle Fourche.
2. *Ictalurus punctatus* (Raf.) Channel Cat. Middle Creek at Belle Fourche.

CATOSTOMIDÆ, OR SUCKERS.

3. *Carpionodes carpio* (Raf.) Carp Sucker. Found by us only in the Belle Fourche.
4. *Pantosteus jordani* Evermann. This species recently described by me as new (Bull. U. S. Fish Com., XII., Art. 2, 51-56, January 27, 1893,) was found by us in most of the streams of the Black Hills, viz: White-wood, Spearfish, Crow, Rapid and Hat creeks, and in the Belle Fourche. For full description, see the Bulletin mentioned above.
5. *Catostomus teres sucklii* Girard. Common Western Sucker. Found in Middle, Crow, Chicken, Rapid, Cottonwood and Hat creeks, and in the Belle Fourche.
6. *Moxostoma macrolepidotum duquesnii* (Le Sueur.) The Belle Fourche and South Fork of the Cheyenne, and in Redwater Creek.

*In his paper on "The North American Species of Salmon and Trout," printed in the U. S. Fish Commission Report for 1872-1873, Dr. Suckley, in giving the habitat of *Salmo lewisi* (*S. mykiss*), credits it to the "Black Hills, Nebraska, Dr. Hayden." I have been unable to verify this reference, and I believe it to be an error.

CYPRINIDÆ, OR MINNOWS.

7. *Hybognathus nuchalis placita* Grd. Western Silvery Minnow. Cottonwood, Hat, and Middle creeks, and South Fork of Cheyenne and Belle Fourche rivers.

8. *Pimephales promelas* Raf. Black-headed Minnow. Middle, Rapid, Cottonwood, and Hat creeks.

9. *Notropis deliciosus* (Grd.) Middle, Rapid, Cottonwood, and Hat creeks, and Belle Fourche River.

10. *Rhinichthys dulcis* (Grd.) Western Dace. Whitewood, Chicken, Crow, Rapid, Cottonwood, and Hat Creeks, Cook's Pond, near Spearfish, and Fall River.

11. *Coursinus dissimilis* (Grd.) Found only in Rapid Creek.

12. *Platygobio gracilis* (Rich.) Flat-headed Minnow. Middle, Cottonwood, and Hat creeks, and Belle Fourche and South Fork of Cheyenne rivers, in all of which it is abundant.

13. *Semotilus atromaculatus* (Mitch.) Chub. Found only in Chicken, Crow, and Rapid Creeks. These are the most western localities from which this fish has been reported.

14. *Leuciscus neogurus* (Cope.) Found by us only in Cox's Lake and Chicken Creek, near Gammon's ranch, S. D.

GADIDÆ, OR COD-FISHES.

15. *Lota lota maculosa* (Le Sueur.) One specimen obtained at Cheyenne Falls. This is the only fresh water representative of the codfish family.

These fifteen species are, so far as known, the only fishes found native to the Black Hills. It is the intention to continue the investigations in that region during a portion of the coming summer, when it is expected that the exact limits in the range of at least some of these species may be made out. It is especially desirable to determine in what streams the spiny-rayed fishes make their nearest approach to this region.

THE PTARMIGAN OF THE ALEUTIAN ISLANDS. By B. W. EVERMANN.

[ABSTRACT.]

It was my good fortune to spend the six months from March to September, 1892; on board the U. S. Fish Commission steamer *Albatross*, which was engaged during that time investigating the habits, abundance and distribution of the fur-seal in the North Pacific and Bering sea. While

carrying on these investigations we touched at a number of places on the mainland of Alaska, and while cruising along the Aleutian chain of islands we visited most of those which are inhabited.

While the study of the birds of these regions was only an incidental part of my work, nevertheless I had opportunity to make considerable collections at Alexandrovsk and Saldovoi in Cook's Inlet, at Nuchek in Prince William Sound, on Kadiak Island, Unalaska, Amaknak, Atka and Attu islands, also upon Bering Island of the Commander group. Among these is a series of ptarmigan that is of much interest.

The species represented are the following: Willow Ptarmigan (*Lagopus lagopus*) and Rock Ptarmigan (*L. rupestris*) from Kadiak Island, Nelson's Ptarmigan (*L. rupestris nelsoni*) from Amaknak and Unalaska islands, Turner's Ptarmigan (*L. rupestris atkensis*) from Atka Island, and an undescribed species from the island of Attu, the most westerly of the Aleutian chain.

The two species from Kadiak Island were collected April 13 and 14, and are interesting as showing the plumage at that season. The Willow Ptarmigan ranges near the bases of the mountains and among the sparse willow growth of the lower portions of the island. At the time of our visit the snow had melted from considerable areas frequented by this species, while higher up the mountains, where we found the Rock Ptarmigan, and where there is little or no woody vegetation, the snow covering everything completely.

The principle of adaptation to environment was clearly illustrated by these two species. The one whose range was in the region still covered entirely with snow had not yet begun to change from winter to summer plumage, not one of the sixty odd specimens collected showing a single brown feather; the plumage of every one was a solid white. Not so, however, with the Willow Ptarmigan. Their plumage had already begun to change gradually with the slowly melting snow, and in most cases the head and neck had almost completely changed to the summer brown, while brown feathers were scattered here and there through the rest of the plumage.

It is easy to see that it is greatly to the advantage of each of these species to change from winter to summer plumage synchronously with the melting snows; too rapid or premature change as well as change too long delayed would defeat the object of protective coloration.

Specimens of Nelson's Ptarmigan were obtained May 19 and 20, and

others in June. Those obtained in May had changed considerably toward the summer dress, while those taken in June were in complete breeding plumage. On May 24 I spent the day on Atka Island, and secured a dozen good specimens of Turner's Ptarmigan. They were usually found low down, either in the lowest heather or among the tall dead grass of the lowest hills. They were always seen in pairs, and were evidently mated. When flushed the male utters a coarse, guttural note, not distinguishable by me from that of Nelson's. Most of their crops were empty, but some were filled with leaves of *Empetrum nigrum*. While the higher parts of the island were still covered with snow, the portions where we found the ptarmigan were almost wholly free of snow, and these birds were, as might be expected, in almost complete summer plumage.

The various species of ptarmigan are, as you know, non-migratory, in this respect resembling our native quail of Indiana; and the individuals found upon any particular island are, of course, practically limited to that one island. That ptarmigan are found upon several islands of the Aleutian chain is due either to the fact that the different islands were at one time connected, thus permitting the ptarmigan to spread over the entire area, or else that individual birds now and then found their way to other islands by being carried across by strong winds. Individuals thus carried to a new island remained there, of course, and, adapting themselves to the new conditions, became well established. In time, the new conditions, differing however slightly from those upon the island from which they came, reacted upon these birds and modified them more or less, until finally they became sufficiently differentiated to be easily distinguished from the ptarmigan of any other island. That differentiation of this character does take place is a well known fact to every student of insular faunas, and the ptarmigan of the Alaskan islands afford excellent illustrations of this important principle. The investigations made by Dr. Stejneger and Prof. Ridgway, some years ago, showed that the ptarmigan of Unalaska Island, of Atka Island, and of Bering Island must be regarded as three distinct species, or sub-species.

Unalaska is about 500 miles from Kadiak; Atka is nearly 400 miles further west; Attu is 500 miles west of Atka, and about 300 miles southeast of Nikolski on Bering Island. It will thus be seen that the island of Attu is quite as much isolated as are the others named, and I was therefore very anxious to secure specimens of ptarmigan from that island

if possible. That ptarmigan were to be found upon Attu Island I knew from the report of Mr. L. M. Turner, who visited the island in 1880-81, but who appears not to have collected any specimens.

The *Albatross* anchored in Chichagof harbor, Attu Island, on the evening of May 28, and I spent the next day on shore climbing over the snowy mountain slopes in search of the ptarmigan; and the search was rewarded by our securing five fine specimens, four males and one female. A comparison of these with the specimens which I had from Unalaska and Atka indicated that there are some well marked differences, and that the Attu Ptarmigan is worthy of at least sub-specific rank. Upon returning to Washington I turned the specimens over to the U. S. National Museum, where they have been examined by Doctors Ridgway, Stejneger, and Merriam, all of whom pronounce it a new and well-marked variety.

LOCAL VARIATIONS. By C. H. EIGENMANN.

[ABSTRACT.]

A detailed comparison of about 400 specimens of *Leuciscus* from the Columbia basin and the Fraser basin showed that each locality has a variety which in the aggregate was different from the varieties of every other locality. The fin rays were found to decrease with the altitude, and in a general way it was noticed that the variation between the specimens of the same species also decreased with the altitude. These facts were demonstrated by diagrams.

MODERN GEOGRAPHICAL DISTRIBUTION OF INSECTS IN INDIANA. By F. M. WEBSTER.

He who studies geographical distribution is, at the very beginning, brought to understand that the area of any one state, or, indeed, any single country, is far too limited in which to work out his problem, as in the majority of cases the influences which make the presence of a species possible lie, largely, outside the boundaries of such state. The entomology of Indiana is only a fragment of the world's entomology and must be studied in connection with its closely related factors. You will therefore, I hope, pardon me for beginning my subject at a long distance from home and with elements seeming at first to have little to do with Indiana insects.

There are currents of air in the heavens and currents of water in both the oceans and inland streams, and all these have their influence on insect distribution. The influences of the Gulf stream of the Atlantic are far reaching in their effects, as will be further explained, while the corresponding current, sweeping northward along the coast of eastern Asia and south along the west coast of North America, is at present less important in its effects, owing largely, perhaps, to the Rocky Mountains and the Great American Desert. There also seem to be currents of insect migration. These, three in number, may be designated as follows: The



Map indicating, approximately, the natural divide between the northern and southern insect faunas, east of the Rocky Mountains.

Pacific coast, Northwestern and Southwestern. With the first we at present have little to do, as owing, possibly, to the combined influences of the mountains and desert intervening between us and the area directly influenced by it, we see little of the insect fauna of the Pacific coast. To the influence of the Rocky Mountains I attribute the extension of Alaskan forms southward to New Mexico. Whether, with the barriers withdrawn, these trans Pacific and sub-arctic species would drift eastward, is a problem which will likely only be solved when some gigantic system of irrigation

shall cause these desert wastes to cover themselves with vegetation. The other two have an influence on the insect fauna of Indiana which we can as yet but vaguely understand. In a paper on "Some Insect Immigrants in Ohio," read before the Ohio Academy of Science, and, later, published in "Science," Vol. XXII., pp. 57-59, and from which notice the map is extracted, we indicated the dividing line between these two currents of insect migrations in the following terms:

"There are, seemingly, two what we may term gateways through which the majority of species that have come to us from the east, have made entrance into the state of Ohio, and, later, spread out over the northwest. The first, and apparently the most important one of these, being at the extreme northeastern part, adjoining Lake Erie, and which we might term the north gate, and, second, the valley of the Ohio river, from a point where it begins to form the eastern boundary of the state, southward—perhaps to Wheeling, W. Va. Now, there also appear to be two great national avenues or highways which insect migrations follow; progressing more rapidly along either one or the other, but not equally so along both, and often following only one; the more sub-tropical species, whether American or introduced, taking the southern or what I would call the Great Southwestern route, while the sub-arctic, including, besides American, such species as have come to us from England or Europe north of latitude 45° north, take what I would term the Great Northwestern route. The division between these two great thoroughfares will be indicated, approximately, by a line drawn from New York City, latitude $40^{\circ} 43'$ north, to St. Louis, Missouri, latitude $38^{\circ} 38'$ north, thence to Pueblo, Colorado, latitude $38^{\circ} 17'$ north (about), the line of separation trending northward, east of St. Louis, under the influence of the Gulf Stream and the Great Lakes, chiefly the former. Of course it is not to be understood that this line is direct, as it is doubtless more or less irregular, and, from its very nature, to some extent unstable, nor is it to be supposed to form a radical boundary, as some northern forms gradually work their way south of it, and *vice versa*. Yet it will, I think, be found approximately correct."

From the foregoing it will be clearly observed that Indiana is itself but a single factor in the determination of the nature of its insect fauna, and, while the extent of its area covered by a species may be largely a matter of local influences, these are not by any means important factors in determining the exact locality where such species shall first appear within its

borders. This is quite aptly illustrated by *Phytonomus punctatus*, Fab., and *Hylesinus trifolii* Muel.* These entered Ohio first at the extreme northeast corner of the state, and there seems to have been a later introduction by the southeast gateway, the current of the Ohio river carrying them down and landing a colony of each in southeast Indiana and southwest Ohio, thus completely disarranging what had previously seemed very probable, viz: that both of these species would cross northern Ohio and make their first entrance into the state from the northeast. As it is, they will probably not do so, but work to the north and west, the two invasions (a second will probably occur in the northeast) meeting somewhere north of the center, west or southwest of Ft. Wayne. Strange as it may appear, an invasion of foreign or American species starting from Quebec, New England or New York, makes its way westward to the south of the Great Lakes instead of to the north. Therefore, species entering Indiana from Michigan are of rare occurrence. Indeed, I do not know of a single one whose advance can be with certainty traced to such a course. *Aphodius fossor*, Linn., may perhaps be an exception, as it is known to have worked southward to Massachusetts from Canada. It was next found at Detroit, Michigan, and I have seen specimens collected about Chicago, while Prof. Wickham reports it from Iowa, he having found it in 1887. There are, however, at present no good collectors in northern Ohio, and it might have followed the usual route along to the south of Lake Erie.

Invasions have also swept over the state from the west, though not many of these are recorded. *Doryphora 10-lineata*, Say, an American species, will amply illustrate the fact of there being a current of insect migration from west to east, as well as one taking the reverse course.

For anything we can now see, this system of currents and counter currents may have thus been going on for ages, and it is fruitless to attempt

* NOTE.—Since the above was written, I learn that this species has been reported from northeast Iowa by Mr. Wallace, of Des Moines. Investigation, however, develops the fact that this report is based on an injury to clover, supposed to have been done by this beetle. There is no evidence showing that it has been observed in Iowa. Mr. E. A. Schwarz, of Washington, reports it from Detroit, Michigan, and the report is doubtless correct; therefore, it may now occur in extreme northeast Indiana, in accordance with our previous anticipations. I wish also to call attention to the fact that this insect, in European catalogues, is placed in the genus *Hylastes*, and, so far as known to the writer, has never been considered as belonging elsewhere. If it belongs to this genus in Europe, it should in the United States, since no striking anatomical changes would follow its transportation from that country to this. If our genera are not in conformity with those of the same name in other countries, then why use a preoccupied name? The idea that this species shall be a *Hylesinus* in America and a *Hylastes* in Europe, is sheer nonsense and should be corrected, either in one country or the other.

to show how many of our now thoroughly established species may have been brought to the state in this manner. This much for the insect current of migration that has passed over our great northwestern route.

In regard to the southwestern route, while it may be said to cover a smaller area of the State, it has, probably, brought a less number of species of foreign origin, while of American species, it may have supplied the state fauna with nearly an equal number. Any one who will take the pains to look into the matter will be surprised at the number of southern species that are hovering about in the vicinity of our dividing line, which marks either their approximate northern limit of occurrence, or else their northern limit of normal abundance. Among the Lepidoptera, *Agraulis vanillæ*, Linn., is a good illustration, as it covers almost exactly the southern area and is found in Indiana only in one of the extreme southern counties. *Argynnis diana*, Cram., is probably another example. On the other hand, *Papilio ajax*, Linn., and *P. cresphontes*, Cram., both southern species, have pushed over and far beyond our line of demarkation. Indeed, it seems probable that the former has reached farther north in western New York than it has along the Atlantic. The same might be said of one of the Orthoptera, *Acridium americanum*, Scudd. I have observed this rarely in southern DeKalb county, northern Illinois, and quite abundantly in southern Illinois, and know it to occur sometimes in exceedingly great numbers in southeast Indiana. It pushes far north of our dividing line, but is abundant only near or to the south of it. The following from "Field and Forest," Vol. II., p. 145, Feb., 1877, will prove interesting in this connection:

"*Acridium americanum*.—Two correspondents, of the Department of Agriculture, writing from Vevay, Indiana, about the middle of last November, reported the visitation in that place of an immense cloud of grasshoppers that literally covered the streets of the town. One of the gentlemen observed, about 5 P. M., dense cumulo stratus clouds in the southwest, gradually overspreading the sky; at 6 o'clock the wind had risen to moderate gusts, and within half an hour a rattling noise was heard against the windows, like that of light hail. On opening the doors, grasshoppers entered in immense numbers, covering the floors, furniture, clothing, &c. The shower continued till 8 o'clock P. M., when the ground was thickly covered, and the boys began to burn them, shoveling them into bonfires. The specimen sent shows the insect to have been the *Acridium americanum*, one of our largest American grasshoppers."

Stagmomantis carolina, Burm., is an inhabitant of southern Indiana, and breeds in the extreme southern portion, and, at least, as far north as Jefferson county. I learn that a female was captured in Indianapolis last year. The line given, however, marks its northern limit of usual occurrence. In Coleoptera, *Dynastes tityus*, Linn., is a good example. It is a southern species, occurring from Central America northeast to southern New York. Its northern limit in Indiana is near the line given on the accompanying map. It breeds in the vicinity of Bloomington, and I have seen a specimen taken at Columbus. *Tetracha virginica*, Linn., whose distribution Schaupp gives as "Texas, Louisiana, Florida, Nebraska and Pennsylvania," I have taken at LaFayette.

In Hemiptera, *Murgantia histrionica*, Hahan, whose southern home is Guatemala and Mexico, began its northward march from Texas about 1866, and has now reached northern New Jersey on the east, occurring in southern Ohio, where it appeared about 1889. It has for quite a number of years been observed in southern Illinois, but seems not to have appeared in Indiana until 1890, when it was observed in Perry county. It also occurs commonly over the southern half of Missouri, and, in fact, covering the whole area south of our dividing line, and, as shown, crowding closely up to it in Ohio, Indiana and Illinois, though it is not likely to extend far beyond this in either of these states. Its slow progress and scanty numbers show it to have nearly reached its northern limit. There are two other members of this order of whose local distribution I wish to speak, the origin of both being enveloped in an obscurity altogether too dense to offer any hope of our ever being able to solve the mysteries of their diffusion. I refer to the Chinch bug, *Blissus leucopterus*, Say, and *Cicada septendecim*, Linn.

The Chinch bug was described by Say from a specimen from the east shore of Virginia, though it is now known to have at that time occurred in destructive numbers in Illinois, and at no great distance from New Harmony, Indiana. In fact, Illinois seems to have been the central point of its greatest abundance—the storm center, so to speak. In Indiana, its destructive area may be approximately included by a line drawn from the northwest corner, near Chicago, to New Albany, and its area of occurrence in noticeable numbers by a line drawn from the same point to Ft. Wayne and the eastern border of Ohio. North of this line, especially in the northern row of counties, the insect can only be found by close collecting. I myself spent a half a day in LaGrange county during a season of great

abundance elsewhere, and found but a single specimen, and this of the short-winged form, which occurs also in New York, being variety (c) of Fitch. I have spent a great deal of time and investigation in trying to unravel the mystery of this distribution, but can now give no reason for the almost total absence of the species in the northeastern portion of the state, while they are overabundant in the opposite direction.

While located in Indiana, an opportunity was offered me to study the distribution of three broods of *Cicada septendecim*, Linn., very carefully. These were Brood XXII., 1885; Brood V., 1888; Brood VIII., 1889. The first of these covered the whole area of the state except a narrow strip of country around the southern extremity of Lake Michigan, the outlines being approximately described by a line commencing at the northern boundary of the state, nearly or quite due north of the city of LaPorte, and extending nearly south-southwest, running a short distance east of Westville, on the L., N. A. & C. R. R., and crossing this railway near Wanatah; then sweeping southwest to the western boundary of the state. This brood probably occupied the territory along the Kankakee river, and extending a short distance northward into Lake and Porter counties.

Brood V., 1888, so far as I have been able to learn, covered almost exactly the area not visited by Brood XXII., and was not observed elsewhere in the state.

Brood VIII., I have definitely recorded from the counties of Brown, Clark, Crawford, Daviess, Dearborn, Floyd, Gibson, Harrison, Johnson, Knox, Lawrence, Monroe, Morgan, Orange, Scott, Tippecanoe, Warwick and Washington. In Harrison county, only, were the insects abundant, and in Tippecanoe county the invasion was only known from a single female captured by the young sons of Dr. E. Test. Broods XXII. and V. are both strong ones, while Brood VIII. is apparently very weak, and, owing to the clearing up of the forests and the attacks of the English sparrow, it will not be surprising if it becomes nearly or quite extinct in Indiana during the next century.

Of the Diptera very little is really known. I am quite sure the two species of Simulium, *S. pecunarium*, Riley, and *S. meridionale*, Riley, both inhabit the southwestern portion of the state. How far northward they may occur I am not able to say. The species found in Franklin county I am sure is different, but it may not be a northern form.

I have thus gone over the subject in a general way, without going into a detailed account of a greater number of species than necessary to illus-

trate my points. To have done so would have required a greater knowledge of local distribution of species than we now possess. What is at present especially needed is intelligent, continuous, persistent local collecting, such as is being done by Mr. Evans, of Evansville, Profs. Blatchley, of Terre Haute, and W. P. Shannon, of Greensburg, and Judge McBride and sons, of Elkhart. It is only by long acquaintance with a locality that we become familiar with its fluctuating insect fauna—species that do not occur every year, and when they do appear are present only in scant numbers and over a limited area.

A careful study of species, other than those here given, may throw much light on the problem of general geographical distribution, and our dividing line is supposed to be correct in a general way, as, of course, there can be no such thing as an exact or continuous line of demarkation. This will of necessity be more or less irregular. Again, a species spreads over an area particularly adapted for its occupancy. But, no sooner is this done than the individuals along the frontier begin to adapt themselves to an environment but slightly unfavorable, and, as their adaptation changes, so do they slowly advance outward from the territory originally occupied. A series of to them favorable seasons might occasion the occupation of a wide margin of adjoining country, while a series of unfavorable seasons might sweep this tide of advance back nearly or quite to the place of its origin. But, as the receding tide of the ocean leaves many pools of water in the depressions of rock, so will there be left, in especially favorable nooks, a few of the insects which will retain their hold and form small, local colonies, of perhaps not more than a few individuals, and the offspring of these will meet the investigator long distances from the real habitat of the species. There is scarcely a collector who does not know of one or more small, secluded areas, in his neighborhood, that are rich in varieties, and which he seldom visits without satisfaction, and frequently he is astonished at his success. How long this ebb and flow has been going on, and how many species have been brought to us in this way, are problems we are yet unable to solve. Therefore, these facts have been brought together, and are here presented, not as a finished, or, indeed, as an advanced study, but rather as a primary outline, to be revised and modified as our knowledge of the geographical distribution of our species shall be enlarged by additional study and research.

AN EXTREME CASE OF PARASITISM. By ROBERT HENSLEY. Published in *American Naturalist*.

A PARTIAL LIST OF NEW SPECIES OF PARASITIC HYMENOPTERA REARED IN INDIANA. By F. M. WEBSTER.

In the following list it is my intention to include only such species as were undescribed at the time they were reared by myself during an eight years residence in the State. These have nearly all been since described and, with but few exceptions, from types furnished by my rearings. The object in presenting this matter is to place it in a form convenient for reference by the future investigator, reference in all cases being given to the original description. I have not as yet been able to complete the list of those now described, and still others remain to be described, but I hope to include all or nearly all of them in a future paper:

1. *Bracon agrili* Ashm. From larvæ of *Agrius fulgens* Lec., burrowing in trunks of maple. La Fayette, April and May. (Proc. U. S. Nat. Mus., 1888, p. 612.)

2. *Bracon diastata* Ashm. From Dipterous leaf miner, *Diastata* n. sp. in corn. La Fayette, June 28, 1886. (Proc. U. S. Nat. Mus., 1888, p. 617.)

3. *Bracon phycidis* Riley, MS. From *Phycis indiginella* Zell. Oxford, July 9, 1884.

4. *Bracon* n. sp. From *Trypeta gibba* Loew, in galls on *Ambrosia artemisiifolia*. La Fayette, May 3, 1889.

5. *Bracon* n. sp. From larvæ of *Rhyssomatus lineaticollis* Say, in seed pods of *Asclepius corymbosa*. La Fayette, March 29, 1889.

Mr. Frederick Blanchard, of Lowell, Mass., in a letter to me, says he has reared *R. lineaticollis* from *Asclepius* in Massachusetts, and that it is there attacked by a Hymenopterous parasite.

6. *Dimeris rufipes* Ashm. Host unknown. La Fayette.

7. *Rhyssalus loxoteniar* Ashm. From *Loxotenidia clemensiana* Fern. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 629.)

8. *Aphidius obscuripes* Ashm. Host unknown. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 660.)

9. *Aphidius pallidus* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 661.)

10. *Lysiphlebus multiarticulatus* Ashm. Host some species of Aphides. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 664.)

11. *Lysiphlebus ribaphidis* Ashm. From *Aphis ribes* on currant. La Grange county, July 12, 1886. (Proc. U. S. Nat. Mus., 1888, p. 664.)
12. *Lysiphlebus cucurbitaphidis* Ashm. From *Siphonophora cucurbitæ* Middleton. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 665.)
13. *Lysiphlebus eragrostaphidis* Ashm. Swept from *Eragrostis*. La Fayette, October 4, 1885. The host is probably *Glyphina eragrostidis* Middleton. (Proc. U. S. Nat. Mus., 1888, p. 665.)
14. *Lysiphlebus mysi* Ashm. From *Mysus ribis* L. La Fayette, See Insect Life, Vol. 3, p. 6. (Proc. U. S. Nat. Mus., 1888, p. 666.)
15. *Lysiphlebus tritici* Ashm. Host *Aphis mali* Fab. La Fayette, October 14, 1888. See Insect Life, Vol. 3, p. 61. (Proc. U. S. Nat. Mus., 1888, p. 668.)
16. *Dicretus americanus* Ashm. From *Siphonophora avenæ* Fabr. Probably Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 669.)
17. *Dicretus brunniventris* Ashm. From *Siphonophora avenæ*. Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 670.)
18. *Dicretus websteri* Ashm. From *Siphonophora avenæ*. Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 669.)
19. *Pachyneuron micans* Howard. From *Siphonophora avenæ* Fab. Goshen. Have also reared it at Wooster, Ohio, from *Aphis* or grass, probably *Aphis mali* Fab. (Insect Life, 3, p. 246.)
20. *Megaspilus niger* Howard. From *Siphonophora avenæ* Fab. La Fayette. (Insect Life, 3, p. 247.)
21. *Encyrtus websteri* Howard. From *Siphonophora avenæ* Fab. La Fayette. (Insect Life, 3, p. 247.)
22. *Encyrtus clisiocampæ* Ashm. From eggs of *Clisiocampa disstri* Hub. Franklin, Ind. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)
23. *Herpestomus plutellæ* Ashm. From *Plutella cruciferarum*. La Fayette; also at Columbus, Ohio. (Proc. U. S. Nat. Mus., 1889, p. 396.)
24. *Orthopelma bimaculatum* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1889, p. 416.)
25. *Limnera flavicincta* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1889, p. 436.)
26. *Zela nigriceps* Riley, MS. From *Crambus zeellus* Fern. Cass, Sullivan county, July 11, 1886.
27. *Acoloides sautidis* Howard. From eggs of spider, *Saitis pulex*. The types were reared in Nebraska by Prof. Lawrence Bruner, but specimens

were several years previously reared by me at Oxford, October, 1884. See Insect Life, Vol. 2, p. 359. (Insect Life, 2, p. 269.)

28. *Meraporus bruchivorus* Ashm. From *Bruchus exiguus* Horn. La Fayette. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)

29. *Catolaccus tylodermae* Ashm. From *Tyloderma foveolatum* Say. La Fayette. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)

30. *Glypta* sp.? From cocoon on red cedar. La Fayette. See Insect Life, Vol. 3, p. 464.

31. *Wesmaelia Rileyi* Ashmead. Although the specimens, six in number, from which the description was drawn, were in the Riley collection and the species named in honor of the possessor, they were reared by me at Oxford, Ind., July 24–August 1, 1884, and sent to the U. S. Department of Agriculture, in whose employ I was at that time. These appeared in a breeding cage in which I was rearing *Toxoptera graminum*, and as there was no other inhabitant of this cage, that species must have been the host. This was the first time the species had been observed. It is not, however, a true Wesmaelid, and represents a rare family not as yet included in our lists. (Proc. U. S. Nat. Mus., 1888, p. 641.)

32. *Pygostolus americanus* Ashmead. (MS.) Reared at LaFayette, Ind., Aug., 1889, from wheat stubble. As this stubble was infested by the Hessian fly and its various parasites, including *Eupelmus allynii* French, and as I also reared from the same lot of stubble, *Acoloides howardii* Ashmead, a spider parasite, *Labes hyphlocybae* Ashmead, *Encyrtus tarsalis* Ashmead, an undetermined species of *Batomus* and a *Homoporus* sp., it is useless to theorize in regard to which of these might have been the host.

33. *Encyrtus tarsalis* Ashmead. (MS.) This was reared with the preceding, and also at LaPorte, Ind.

34. *Encyrtus brunnipennis* Ashmead. (MS.) Reared from wheat stubble from LaPorte, Ind., August, 1889.

35. *Ateleopterus tarsalis* Ashmead. Reared at LaFayette, Ind., from *Silvanus surinamensis*, infesting stored grain. This had previously been reared at Washington, D. C., by Mr. Ashmead, from the same insect infesting raisins. (Bull. U. S. Nat. Mus., No. 45, p. 45, 1893.)

36. *Cacus acanthi* Riley, Nov. Gen., et. sp. Reared from the eggs of *Acanthus nireus* at LaFayette, Ind. This species is the type of the genus, and the only one whose parasitism is known. (Bull. U. S. Nat. Mus., No. 45., pp. 223–4, 1893.)

Platygaster error Fitch. Reared June 14, 1884, at Oxford, Ind., from

larvæ of *Diplosis tritici*. The original describer was in doubt as to whether this was really a parasite of this species, the wheat midge, or not. Re-described by Mr. Ashmead from specimens reared by myself as above. (Bull. U. S. Nat. Mus., No. 45, p. 291, 1893.)

A MITE, PROBABLY HYPODERAS COLUMBE, PARASITIC IN THE PIGEON. By W. W. NORMAN.

THE LOCUSTIDÆ OF INDIANA. By W. S. BLATCHLEY, Terre Haute, Indiana.

The order of insects known as the *Orthoptera* comprises seven families, three of which are alike in having the posterior femora more or less enlarged for leaping; the three being therefore classed together in a sub-order called the *Saltatoria*, or jumpers.

In the present paper we have to deal with that family of this sub-order known as the *Locustidæ*, which comprises those insects commonly called katydids, green grasshoppers, and stone or camel crickets.

The distinguishing characters of the members of the family *Locustidæ* are the long, slender, tapering, many-jointed antennæ; the almost universal absence of ocelli or simple eyes; the four jointed* tarsi or feet; and the ensiform or falcate ovipositor of the females which is made of four flattened plates; the males having, in many instances, abdominal appendages corresponding to the parts of the ovipositor, which are used as clasping organs. The tegmina or wing covers, when present, slope obliquely downwards, instead of being bent abruptly, as in the *Gryllidæ*; and in most cases the wings are longer than the tegmina.

The stridulating or musical organ of the males is quite similar in structure to that of the male cricket, being found at the base of the overlapping dorsal surface of the tegmina and usually consisting of a transparent membrane, of a more or less rounded form, which is crossed by a prominent curved vein, which on the under side bears a single row of minute file like teeth. In stridulating the wing covers are moved apart and then shuffled together again when these teeth are rubbed over a vein on the

* The members of the genus *Dalmanella*, no one of which occurs in Indiana, have the fore and hind tarsi three-jointed.

upper surface of the other wing cover, producing the familiar, so called "katydid" sound. Each of the different species makes a distinct call or note of its own, and many of them have two calls, one which they use by night and the other by day. Any one who will pay close attention to these different calls can soon learn to distinguish each species by its note as readily as the ornithologist can recognize different species of birds in the same manner. The ear of these insects, when present, is also similar in structure and position to that of the cricket's, being an oblong or oval cavity covered with a transparent or whitish membrane, and situated near the basal end of the front tibiae.

The young of *Locustidae*, like those of the other families of the order, when hatched from the egg resemble the adults in form but are wholly wingless. As they increase in size they moult or shed the skin five times, the wings each time becoming more apparent, until after the fifth moult when they appear fully developed, and the insect is mature, or full grown, never increasing in size thereafter. Throughout their entire lives they are active, greedy feeders, mostly herbivorous in habit; and where present in numbers necessarily do much harm to growing vegetation.

Among the families of Orthoptera the *Locustidae* take a rank second only to the *Gryllidae*. The high specialization of the ovipositor of the female and the perfection of structure of the stridulating organ of the male place these two families above all others in the scale of Orthopteron life. That the two are very closely related can be readily seen by any one who will carefully compare them, organ with organ. The *Gryllidae* are placed first, however, by most entomologists, as the great variety of form of almost any given organ among them, when compared with its relative uniformity of structure among the *Locustidae*, seems to indicate the higher rank of the former.*

In the number of species in any given locality the *Locustidae* far outrank the *Gryllidae*, being excelled in this respect among the other Orthopteron families only by the *Acrididae* or locusts. In Indiana thirty-nine species of *Locustidae* are known to occur and are listed in the present paper, specimens of all being in my private collection. This is eleven more than are known in any other state from which lists have been published; McNeill having listed twenty-seven from Illinois; Smith, twenty-eight from New Jersey; Osborne, twenty-four from Iowa, and Fernald sixteen from all New England.

* Scudder, Proc. Bost. Soc. Nat. Hist., XII., 1868, 233.

Undoubtedly other species occur in Indiana, especially in the southern half of the state, but having had to rely almost wholly upon my own collecting, which has been done in Putnam, Vigo, Montgomery, Wabash, Marshall and Fulton counties, the eastern and southern parts of the state are wholly unrepresented in the list. Three persons, Prof. E. E. Slick, of Michigan City; Prof. W. P. Hay, formerly of Irvington, and Mr. W. A. Riley, of Greencastle, have sent me small collections from their respective localities which have aided me much in recording the distribution of certain species.

To Mr. S. H. Scudder, of Cambridge, Mass., I am indebted for the loan of typical specimens of the genus *Ceuthophilus* for comparison; and to Prof. Lawrence Bruner, of Lincoln, Nebraska, for aid in identifying and verifying certain species. Prof. Bruner also furnished me some valuable notes concerning the general distribution of a number of the species, which are incorporated under their respective species in the list below.

The descriptions of such species of *Locustidae* as occur in the eastern United States are scattered through many scientific books and papers which are for the most part inaccessible to beginners in entomology. I have thought it best, therefore, to prepare a synopsis of the sub-families and of the genera under each sub-family, which are represented in the state. A short description of each species, with such notes concerning its distribution, food, habits, and comparative abundance, as have been gathered during my collecting, is also given, together with a synonymy of the species, as far as obtainable from the works at hand.

The following is a bibliography of authors and works to which reference is made in this synonymy:

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A SYNOPSIS OF THE SUB FAMILIES OF LOCUSTIDÆ FOUND IN INDIANA.

- a. Tegmina and wings present.
 - b. Prosternal spines absent; vertex rounded or deflexed without spine, tubercle or cone; tegmina always shorter than the wings PHANEROPTERINÆ. p. 97
 - bb. Prosternal spines present; vertex either terminating in a sharp flat spine or produced upwards and forwards in a rounded tubercle or prominent cone.
 - c. Wing covers leaf like, broadly expanded in the middle, concave within, longer than the wings; vertex terminating in a sharp flat spine . . . PSEUDOPHYLLINÆ. p. 109
 - cc. Wing covers narrow, not expanded in the middle, of en shorter than the wings; vertex terminating in a rounded tubercle or prominent cone . CONOCEPHALINÆ. p. 111
- aa. Tegmina and wings absent, or the former rudimentary.
 - d. Pronotum short, not covering the whole top of the thorax; prosternal spines absent . . STENOPELMATINÆ. p. 140
 - dd. Pronotum extending back to the abdomen; prosternal spines present DECTICIDINÆ. p. 149

LOCUSTIDÆ.

PHANEROPTERINÆ.

The species of this sub-family are among the largest of our Locustidæ, and, with those of the next, are commonly known as "Katydid," The apex of the head is obtuse or rounded, without cone or spine, and the prosternum is unarmed. The wing covers are shorter than the wings, usually expanded in the middle, and of a bright, uniform green color. The wings are folded like a fan and are long and strong, the insects being flyers rather than leapers. The hind limbs, being seldom used except to give themselves an upward impetus at the beginning of flight, while long and slender, are proportionally much smaller in diameter than in the sub-family *Conocephalinæ*, whose members leap rather than fly.

The "Katydid" are the most arboreal of all the Locustidæ, the great majority of them passing their entire lives on shrubs and trees where they feed upon the leaves and tender twigs, and when present in numbers often do excessive injury. The color and form of their wings serve admirably to protect them against their worst foes, the birds; and as they live a solitary life, *i. e.*, do not flock together in numbers as do the green grasshoppers, they are but seldom noticed by man. Their love calls, or songs, however, make the welkin ring at night from mid-August until after heavy frost, and though but one or two of the eight species found in the State make a note in any way resembling the syllables "Katy did, she did," yet all are accredited with this sound by the casual observer, and hence the common name usually given to the members of this sub-family. Their call is seldom made by day for the obvious reason that it might attract the attention of the birds and so lead to the destruction of the songster. As twilight approaches, however, the male of each species begins his peculiar note which is kept up with little or no intermission until the approach of day warns him that his feathered enemies will soon be on the alert, and that silence will be, for a time, the best policy to pursue.

From the other Locustidæ, the Katydid differ widely in their habits of oviposition, the eggs not being deposited in the earth or in twigs, but are usually glued fast in double rows to the outer surface of slender twigs or on the edges of leaves. The eggs of the most common species appear like small flattened hemp seeds, and usually overlap one another in the row in which they are placed. On account of this method of oviposition, the ovipositors of the "Katydid" are broader, more curved, and more obtuse

at the end than in the other sub-families whose members oviposit in the earth or in stems of grass. This sub-family is represented in Indiana, so far as known, by three genera and eight species.

KEY TO GENERA OF PHANEROPTERINÆ.

- a. Wing covers of equal breadth throughout; supra-anal plate of male with a long decurved spine which is notched at the end I. SCUDDERIA.
- aa. Wing covers widest in the middle; supra-anal plate of male not as above.
 - b. Hind femora but little if any shorter than wing covers; ovipositor well developed, curved gradually upwards II. AMBLYCORYPHA.
 - bb. Hind femora much shorter than wing covers; ovipositor very short, turned abruptly upwards III. MICROCENTRUM.

I. SCUDDERIA, Stål (1873).

This genus includes Katydids of medium size, with the wing covers long, narrow, of nearly equal width throughout, and rounded at the ends. The vertex is deflexed, compressed, and hollowed out on either side for the better accomodation of the eyes, which are nearly hemispherical. The hind femora are long and slender, almost equalling the length of the wing covers in some of the species. The ovipositor is short, broad, curved sharply upwards, and has the apical third finely crenate on both margins. The males are readily distinguished from those of other genera by having both anal plates projected into long curved processes; the one from the supra-anal plate curving downwards and notched or forked at the end, that from the sub-anal curving upwards, and likewise notched. The form of these processes, together with that of the notches serve as valuable characters in distinguishing the species. Six species have been described from the United States, four of which occur in Indiana.

- a. Length of posterior femora 28 or more mm.*
- b. Notch of supra-anal spine of male square with a slight median tooth, almost as wide as the middle of the upturned sub-anal spine; the lateral processes slender and compressed.

*NOTE.—The measurements in this paper are given in millimeters, an inch being equal to very nearly twenty-five millimeters. The measurements given are, when possible, the average of a number of specimens, and the "length of body" does not include the sexual appendages of male nor the ovipositor of female.

1. *SCUDDERIA CURVICAUDA*, (DeGeer.)*

“*Locusta curvicauda*, DeGeer, Mem., III., 1773, 446, Pl. 38, fig. 3.”

Phaneroptera curvicauda, Burmeister, Handbuch der Ent., II., 1838, 690.

Scudder, Bost. Journ. Nat. Hist., VII., 1862, 448.

(In part.)

Uhler, in Harris' Ins. Inj. to Veg., 1862, 161.

(Note.—In part.)

Scudderia curvicauda, Brunner, Monogr. der Phanerop., 1878.

Riley, Stand. Nat. Hist., II., 1884, 191.

Comstock, Int. to Ent., I., 1888, 118.

Fernald, Orth. N. Eng., 1888, 22. (In part.)

McNeill, Psyche, VI., 1891, 21. (Song of.)

Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 68.

(Song of.)

Smith, Bull. Ag. Exp. Stat. of N. J., No. 90, 1892, 24.

Phaneroptera septentrionalis, Serville, Hist. Nat. des Orth., 1839., 416.

Tegmina, wings and legs bright grass green; body and face somewhat paler, approaching a whitish in dried specimens. Lateral carinae of the pronotum with a yellowish line. Posterior femora very slender, armed beneath on inner carina with three or four minute spines.

Measurements: Male—Length of body, 22 mm.; of tegmina, 37.5 mm.; of wings beyond the tegmina, 6 mm.; of posterior femora, 30 mm.; of pronotum, 6.5 mm. Female—Length of body 25 mm.; of posterior femora, 32 mm.; of ovipositor, 7 mm. Width of tegmina, 6.5 mm.

Curvicauda is a common insect in the central and southern half of Indiana, but northward seems to be replaced by *S. furculata*. The former is probably less arboreal than any other species of Katydid, as it is often found clinging to the tall, coarse grasses and sedges which grow near the borders of ponds and in damp ravines, and to the coarse weeds along the margins of prairies and meadows. When approached it flies readily in a zigzag, noiseless manner for a long distance to another clump of grass or weeds, or to the lower branches of an oak, a tree in which it delights to dwell.

The eggs are laid in the margins of leaves between the upper and lower epidermis, and are so thin that they are not noticeable except when the leaf is held between one's self and the light. Of the song or note made by the male of *curvicauda* McNeill (*loc. cit.*) says: “The note cannot be

*When the author of a species referred it to a different genus from that in which it is now included, his name is put in parenthesis.

supposed to represent more than the first two syllables of the 'Katy did' or 'Katy didn't' of its congeners. It is made but once, and the rasping, jerky sound has been very well represented as *barwi*."

Curvicauda is a species of wide distribution, occurring throughout the eastern United States, and as far west as the Rocky Mountains. In Central Indiana it reaches maturity about the 25th of July.

- bb. Notch of supra-anal spine of male acute and much narrower than the middle of the upcurved sub-anal spine; the lateral processes (at side of notch) broadly rounded with the lower margin thinner.

2. SCUDDERIA FURCULATA, Brunner.

Scudderia furculata, Brunner, Monog. der Phanerop., 1878.

Smith, Cat., Insects found in N. J., 1890, 410.

Id., Bull. Agr. Exp. Stat. of N. J., No. 90, 24, pl. II., Fig. 4.

Somewhat larger than *curvicauda* and closely resembling that species in general appearance, the females of the two being difficult to distinguish except by the measurements; the males readily separated by the different form of the notch of the supra-anal spine. The general color is the same, but the yellow carinal line of the pronotum is less distinct or wholly wanting in *furculata*, and the apical third of wings is usually a transparent reddish brown. The wing covers of the latter are broader and the posterior femora proportionally a little shorter.

Measurements: Male—Length of body, 23 mm.; of tegmina, 37.5 mm., of posterior femora, 30 mm.; of pronotum, 6 mm. Width of tegmina 8 mm. Female—Length of body, 25 mm.; of tegmina, 38 mm.; of posterior femora, 33 mm.; of ovipositor, 7 mm. Width of tegmina, 8.5 mm.

According to Bruner* *furculata* is usually more southern in its distribution than *curvicauda*, but in Indiana this distribution seems reversed, as the latter is much the more common in Vigo and Putnam counties, while in Marshall and Fulton counties, 150 miles further north, it is very scarce and *furculata* very common. A single male was taken from an oak grove on the border of Lake Maxinkuckee in Marshall county, on August 1st, and on the 26th of the same month it was found in numbers at the same place, and also about the borders of a large tamarack swamp in Fulton county. Its habits of flight and song, as far as noted, are essentially the same as those of *curvicauda*, noted above.

*Mss. Notes.

In New Jersey, according to Smith (*loc. cit.*), *furculata* is very common on cranberry bogs, and destroys many of the berries. It will probably be found to occur throughout Indiana near the borders of the larger ponds, lakes and marshes.

aa. Length of posterior femora 22 or 23 mm.

3. *SCUDDERIA FURCATA*, Brunner. The Fork-tailed Katydid.

Scudderia furcata, Brunner, Monog. der Phanerop., 1878.

Brunner, Bull. Washb. Coll. Lab. Nat. Hist., I.,
1885, 127.

McNeill, Psyche, VI., 1891, 21.

Smith, Bull. Agr. Exp. Stat. of N. J., No. 90, 1892,
31.

Phaneroptera curvicauda, Riley, Sixth Rep. St. Ent. Mo., 1874, 164, fig.
51. (Text in part. Not fig. 50.)

This is one of the smallest, and at the same time, our most common species of the genus. The general color is a dark leaf green, the head and pronotum paler; the latter without trace of yellow on its carinae. The anterior margin of the pronotum is but slightly narrower than the posterior, whereas in the two preceding species the difference in width is plainly perceptible. The notch of the supra-anal spine of the male is deep and rounded, forming a curious fork-like appendage, the lateral processes of which are much swollen.

Measurements: Male—Length of body, 16 mm.; of tegmina, 31 mm.; of posterior femora, 23 mm.; of pronotum, 5 mm. Width of tegmina, 6 mm. Female—Length of body, 20 mm., of tegmina, 30 mm.; of posterior femora, 22 mm.; of ovipositor, 5 mm.

In Central and Southern Indiana the Fork-tailed Katydid is most frequently seen on the low bushes and trees about the margin of thickets and along fence rows, but in the prairie country north it frequents coarse grasses and weeds in company with the preceding species. Its flight is noiseless and seemingly without direction, and is not so prolonged as that of *S. curvicauda*. Dr. C. V. Riley (*loc. cit.*) gives the following account of the egg laying habits of *furcata*: "The female stations herself firmly by the middle and hind legs on twigs or leaves contiguous to the one selected to receive the eggs. This leaf is then grasped by the front feet and held in a vertical position, while the edge is slightly gnawed or pared off by the jaws to facilitate the entrance of the point of the ovipositor. When thi

is done the abdomen is curved under and brought forward, and the ovipositor is seized on its convex edge by the mandibles and maxillæ, which, with the aid of the palpi, guide the point to that portion of the leaf prepared to receive it. After gentle, but repeated efforts, the point of the instrument is finally inserted between the tissues of the leaf, and gradually pushed in to more than half its length. As soon as the cavity is formed, the egg is extruded, and passed slowly between the semi-transparent blades of the ovipositor. As the egg leaves the ovipositor the latter is gradually withdrawn, while the egg remains in the leaf, retained in its place, probably, by a viscid fluid that is exuded with it. As many as five of the eggs are sometimes deposited in one row in the same leaf but more often they are single."

This is the most common species of the genus, in the United States, and is quite widely distributed over the country from the Atlantic to the Pacific. In Indiana it has been found in numbers in every county in which collections have been made. The first mature specimens appear about August 5th but it does not become plentiful before the middle of the month.

aaa. Length of posterior femora less than 20 mm.

4. SCUDDERIA ANGUSTIFOLIA (Harris). The Narrow-winged Katydid.

Phaneroptera angustifolia Harris' Ins. Inj. to Veg., 1862, 161, fig. 76.

Scudderia angustifolia, Brunner, Monog. der Phanerop. 1878.

Smith, Cat. Ins. N. J., 1890, 410.

Scudder, Rep. Ent. Soc. Ont. XXIII., 1892. (Note of set to music.)

Phaneroptera curvicauda, Uhler in Harris' Ins. Inj. to Veg., 1862, 161. (Note. In part.)

Scudder, Bost. Journ. Nat Hist., VII., 1862, 448. (In part.)

Id., Am. Nat. II., 1868, 117, (Song of.)

Id.; Distrib. Ins. N. Hamp., 1874, 366. (Song of set to music.)

Riley, Sixth Rep. St. Ent. Mo. 1874, 164, fig. 50. (Not text nor fig. 51.)

Scudderia curvicauda Fernald, Orth. N. Eng., 1888, 22. (In part.)

(Not *Scudderia curvicauda*), (DeGeer.)

This Katydid occurs in abundance in New England and the Middle Atlantic states, and in the past has been confounded by many writers both with *S. curvicauda* and with *S. furcata*. In size, general appearance and structure of anal spines of male it is very similar to *furcata*, but may readily be known by its shorter posterior femora, and by its narrower wing covers.

Measurements: Male—Length of body, 14 mm., of tegmina, 26 mm.; of posterior femora, 19 mm.; of pronotum, 4 mm. Width of tegmina, 5 mm. Female—Length of body, 19 mm.; of tegmina, 25 mm.; of ovipositor, 5.5 mm.

The male of *angustifolia* is our smallest member of the genus. In Indiana it is known only from Fulton county, several specimens of both sexes having been taken on October 7th, from the borders of a peat bog in a tamarack swamp, near Kewanna. This, as far as known, is its first record west of New Jersey. It will probably be found to occur only about the bogs and swamps of the northern half of the State.

Mr. S. H. Scudder, who has studied carefully the songs of many species of Orthoptera and has even set a number of them, including that of *angustifolia*, to music, has given a pleasing account of its song* from which I give the following extract: "It is more noisy by night than by day; and the songs differ considerably at these two times. The day song is given only during sunshine, the other by night and in cloudy weather. I first noticed this while watching one of the little creatures close beside me; as a cloud passed over the sun he suddenly changed his note to one with which I was already familiar, but without knowing to what insect it belonged. At the same time all the individuals around me, whose similar day song I had heard, began to respond with the night cry; the cloud passed away, and the original note was resumed on all sides. Judging that they preferred the night song to that of the day, from their increased stridulation during the former period, I imitated the night song during sunshine, and obtained an immediate response in the same language. The experiment proved that the insects could hear as well as sing. * * *

The note by day is *b z r w i* and lasts for one-third of a second. The night song consists of a repetition, ordinarily eight times, of a note which sounds like *t c h w*. It is repeated at the rate of five times in three quarters of a second, making each note half the length of the day note."

*Distribution of Insects in New Hampshire, 1874, 366.

II. AMBLYCORYPHA, Stål (1873.)

Size medium ; wing covers slightly expanded in the middle, regularly rounded at the ends, a little shorter than, or but slightly exceeding, the posterior femora; vertex broad, deflexed but not compressed, without spines; eyes elliptical; stridulating organ of male, brownish, opaque, traversed by a strong green cross vein; ovipositor broad, of medium length, curved gradually upwards from the middle, obtuse or rounded at the end, and with the apical half sharply and strongly serrate on both edges; anal plates of male not prolonged.

Seven species of this genus, which is confined to North America, have been described from the United States. Of these, three have been found in Indiana.

- a. Tegmina about 37 mm. in length; exceeding the tip of posterior femora.

5. AMBLYCORYPHA OBLONGIFOLIA, (DeGeer.) The Oblong Leaf-winged Katy-did.

Locusta oblongifolia, DeGeer, "Mem., III., 1873, 445, pl. 38, fig. 2."

Phylloptera oblongifolia, Burmeister, Handbuch der Ent., II., 1838, 693.

Harris, Ins. Inj. to Veg., 1862, 159. (Text only.)

Scudder, Bost. Journ. Nat. Hist., VII., 1862, 444.

Id., Distb. Ins. in N. Hamp., 1874, 366.

Id., Am. Encyc. Ed., 1881, VIII., 170. (Text only.)

Rathvon, U. S. Agr. Rep., 1862, 382.

Thomas, Trans. Ill. St. Agr. Soc., V., 1865, 445.

Amblycorypha oblongifolia, Riley, Stand. Nat. Hist., II., 1884, 188.

Bruner, Bull. Washb. Coll. Lab. Nat. Hist.,
I., 1886, 195.

Comstock, Int. to Entom., I., 1888, 116.

Fernald, Orth. N. Eng., 1888, 21.

McNeill, Psyche, VI., 1891, 21.

Scudder, Rep. Ent. Soc. Ont., XXIII., 1892,
68. (Song of.)

The largest of the three species occurring in the state, measuring about 45 mm. to the end of the wing covers, which are 3.3 times as long as wide. Wings exceeding the wing covers by 6.5 mm. Anterior margin of pronotum much narrower than the posterior, the lateral carinae sharply defined. Inner, lower carina of posterior femora armed with ten or more rather

strong teeth. General color a bright pea-green, the shrilling organ of male brownish with a heavy green cross vein. The abdomen yellowish or brownish green.

Measurements: Male—Length of body, 21 mm.; of tegmina, 38 mm.; of posterior femora, 30 mm.; of pronotum 6.5 mm. Female—Length of body, 23 mm.; of tegmina, 36 mm., of posterior femora, 31 mm.; of ovipositor, 11.5 mm. Width of tegmina of male, 11.5 mm.

This species is rather common throughout the state from August 1st to October, frequenting the shrubbery along fence rows and the edges of thickets and woods, especially in damp localities; and when flushed, flies with a kind of whirring noise, alighting on fence or the lower branch of tree. I have not distinguished the note made by the male, but McNeill (*loc. cit.*), says that it is a "quick, shuffling sound which resembles "Katy" or "Katydid" very slightly."

aa. Tegmina less than 30 mm. in length; sometimes reaching but not exceeding the tip of posterior femora.

b. Greatest breadth of tegmina contained less than three times in their length; ovipositor strongly curved.

6. *AMBLYCORYPHA ROTUNDIFOLIA*, (Scudder.) The Round-winged Katydid.

Phylloptera rotundifolia, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 445.

Amblycorypha rotundifolia, Brunner, Monogr. der Phanerop., 1878.

Scudder, Proc. Bost. Soc. Nat. Hist., XIX., 1877, 83.

Id., Am. Encyc., VIII., Ed. 1881, 170. (Fig. only.)

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 68. (Song of.)

Riley, Stand. Nat. Hist., II., 1884, 188, fig. 265.

Comstock, Int. Ent., I., 1888, 116.

Fernald, Orth., N. Eng., 1888, 21.

McNeill, Psyche, VI., 1891, 22.

Phylloptera oblongifolia, Harris, Ins. Inj. to Veg, 1862, fig. 75. (Not text.)

Riley, Sixth Rep. St. Ent. Mo., 1874, 169, fig. 55. (Text in part.)

Length about 32 mm. to end of tegmina, which are proportionally much broader than those of *oblongifolia*. Posterior femora reaching tip of tegmina in male, a little longer in the female; armed on the lower, inner carina with four or five minute teeth. Anterior margin of pronotum, es-

pecially in the female, but little narrower than posterior; the lateral carinae somewhat rounded. The ovipositor is more curved and more strongly serrate than in either the preceding or the following species. The color is essentially the same as that of *oblongifolia*.

Measurements: Male—Length of body, 19 mm.; of tegmina, 27 mm.; of posterior femora, 25 mm.; of pronotum, 5 mm.; width of tegmina, 10 mm. Female—Length of body, 20 mm.; of tegmina, 27 mm.; of pronotum, 6 mm.; of ovipositor, 10 mm.; width of tegmina, 11 mm.

As far as my observation goes, *rotundifolia* is, by far, the most common member of *Amblycorypha* found in Indiana. It is more of a terrestrial species than the preceding, being often seen on the ground, or on the clumps of tall grass and weeds, which grow in damp ravines. Its flight is comparatively noiseless and less prolonged than that of *oblongifolia*. In Central Indiana it makes its first appearance about the fifth of August. Of its note, Mr. Scudder says: "This insect stridulates both by day and by night, and without variation. The song consists of from two to four notes—sounding like *chic-a-chee*, repeated rapidly so as to be almost confounded, and when three requiring just one-third of a second; the song is repeated at will, generally once in about five seconds, for an indefinite length of time."

bb. Greatest breadth of wing covers contained from $3\frac{1}{2}$ to $3\frac{1}{2}$ times in their length; ovipositor but moderately curved.

7. *AMBLYCORYPHA UHLERI*, Brunner. Uhler's Katydid.

Amblycorypha uhleri, Brunner, Monogr. der Phanerop, 1878.

Comstock, Int. to Ent., I., 1888, 116.

Smith, Cat. Ins. of N. Jer., 1890, 409.

Our smallest species of the genus measuring but about 27 mm. to end of tegmina. Posterior femora armed as in *rotundifolia*, slightly exceeding the tegmina in both sexes. Pronotum narrower in front, the anterior half of lateral carinae rounded, the posterior, rather sharp. The male with longer wings and narrower tegmina than the female. Ovipositor less curved than in either of the other species, the apical half with comparatively strong serrations on both margins. General color, a light, grass green.

Measurements: Male—Length of body, 14 mm.; of tegmina, 23.5 mm.; of hind femora, 20 mm.; of wings beyond tegmina, 5 mm. Female—Length of body, 17.5 mm.; of tegmina 20.5 mm.; of hind femora, 21.5 mm.; of wings beyond tegmina, 3 mm.; of ovipositor, 8.5 mm.

Much less common than either of the preceding, having been noted, as far as known, only in Vigo county, where it frequents the tall sedges and willows bordering the large ponds in the Wabash River bottoms. The young feed upon the leaves of the scarlet oak, *Quercus coccinea*, Wang., and the perfect insect is often found on or beneath this tree. It has been recorded before from New Jersey, Maryland, and the District of Columbia. August 12 and 27th.*

III. MICROCENTRUM, Scudder (1862.)

Size large. Wing covers moderately expanded in the middle, much longer than the posterior femora, and with the outer border sloping off quite sharply, thus causing the tip to be more pointed than in *Amblycorypha*. Vertex much as in that genus, slightly furrowed. Eyes broadly oval, very prominent. Hind legs slender and very short, the femora but little more than half as long as the tegmina. Ovipositor very short, bent abruptly upwards, bluntly pointed, and with the apical third finely serrate above. Anal plates of male not prolonged.

"This genus differs from *Amblycorypha*, to which it is most nearly allied, especially by the cut of the wing covers and the shortness of the hind legs and ovipositor."—Scudder.

But one species is known to occur in Indiana.

8. MICROCENTRUM LAURIFOLIUM, (L.) The Larger Angular-winged Katydid. The Oblique-winged Katydid.

"*Gryllus laurifolius* L., Syst. Nat. II., 1767, 695, No. 17."

Phylloptera laurifolia, Burmeister, Handb. d. Ent., II., 1838, 693.

Serville, Hist. Nat. des Orth., 1839, 404.

Microcentrum laurifolium, Bruner, Bull. Washb. Coll. Nat. Hist., I., 1885, 127.

Fernald, Orth. N. Eng., 1888, 21.

McNeill, Psyche, VI., 1891, 22.

Smith, Cat. Ins. N. J., 1890, 409.

Microcentrum affiliatum, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 447, fig 5.

Riley, Stand. Nat. Hist., II., 1884, 191.

Comstock, Int. to Ent., I., 1888, 116.

Microcentrus retinerris, Riley, Sixth Rep. Stat. Ent. Mo., 1874, 155, figs. 43-47.

* Unless otherwise stated, the dates given in this paper are those on which the first mature insects have been taken in Central Indiana.

Microcentrum retinervis, Id., Stand. Nat. Hist., II., 1884, 188. fig. 266, (Not
Microcentrum retinervis, Burm.)

This is the largest species of "Katydid" found in the State, both sexes measuring two inches and more to the end of the wings. The general color is light, grass green, the body yellowish green, lighter beneath. The vertex is quite broad, with its center hollowed out so as to form a shallow pit, which is more prominent in the male. The pronotum is about as broad as long, its anterior margin a little concave and usually possessing a slight median tooth, though this is sometimes obsolete, or is replaced with a shallow notch. The overlapping dorsal surface of the wing covers form a sharp and prominent angle with the lateral portions, whence the common name.

Measurements: Male—Length of body, 25 mm.; of tegmina, 42 mm.; of posterior femora, 22.5 mm.; of pronotum, 6 mm.; width of tegmina, 13 mm. Female—Length of body, 30 mm.; of tegmina 46 mm.; of posterior femora, 24 mm.; of ovipositor, 5 mm.; width of tegmina, 14 mm.

In the country it is this insect which is most commonly called "the Katydid," and the note of *Cyrtophyllus concavus* is usually attributed to it but its true note may be represented "by the syllable 'tic,' repeated from eight to twenty times at the rate of about four to the second."* It is evidently attracted by light, being often found in the gutters beneath the electric lights in the larger cities and towns. It occurs, probably, throughout the State, but is more common southward and is nowhere found in sufficient numbers to be injurious. The eggs are usually glued in double rows on the sides of slender twigs, which have been previously roughened with the jaws and otherwise prepared for a place of deposit. The two rows are contiguous and the eggs of one alternate with those of the other. Those of the same row overlap about one-fourth of their length. They are of a grayish brown color, long oval in shape, very flat, and measure 5.5x3 mm. They are usually deposited in September, hatch the following May, and the young, in Central Indiana, reach maturity during the first half of August.

The insect whose life history was so well written up by Dr. C. V. Riley, in his Sixth Missouri Report, under the name of *Microcentrus retinervis*, is, in my opinion, the present species, since the measurements of the figures there given correspond exactly with those given above of *laurifolium*. The true *M. retinervis* of Burmeister is found in the eastern United States and

*McNeill, (*loc. cit.*)

probably occurs in Indiana, but has not, as yet, been noted. It is considerably smaller* than *laurifolium*, and with the general color more of a yellowish green.

PSEUDOPHYLLINÆ.

This sub-family is represented in Indiana by the single genus *Cyrtophyllus* the leading characters of which are given below.

IV. CYRTOPHYLLUS, Burmeister (1838).

The members of this genus are at once distinguished from all other Locustidæ by the broad leaf-like form of the tegmina which are longer than the wings, obtuse and rounded at the end, and concave or hollowed within. The vertex extends forward between the eyes in the form of a small flat spine and the prosternum is armed with two sharp spines. Eyes small, globose. The "shrilling" organ of the male is brown in color, with the central portion as transparent as glass, and is set in a strong half oval frame. Ovipositor broad, with the apical half up-curved and denticulate below; apex rather sharply pointed. Sub-anal plate of male produced into a long paddle shaped appendage which is grooved on the upper side.

But two species occur in the United States only one of which is rather common in Indiana.

9. CYRTOPHYLLUS CONCAVUS, (Harris.) The True Katydid. The Broad-winged Katydid.

Pterophylla concava, Harris, Encyclopædia Americana, VIII., 1831, 42.

Platyphyllum concavum, Harris, Ins. Inj. to Veg., 1862, 158, fig. 74.

Walsh, Proc. Ent. Soc. Phil., III., 1864, 233.

Thomas, Trans. Ill. St. Ag. Soc., V., 1865, 445.

Riley, Sixth Rep. St. Ent. Mo., 1874, 167, figs. 52-54.

Cyrtophyllus concavus, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 444.

Id., Encyc. Americ. Ed., 1881, IX., 772, fig.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 70, fig. 46.

(Note of set to music).

Thomas, Trans. Dav. Acad. Nat. Sci., I., 1876, 267.

Packard, Guide to Stud. Ins., 1883, 566, fig. 563.

Riley, Stand. Nat. Hist., II., 1884, 187, fig. 264.

*The measurements given by Burmeister are: length of body, 5-6 of an in.; of tegmina, 1½ in.

Comstock, Int. to Ent., I., 1888, 115.

Fernald, Orth., N. Eng., 1888, 20, fig. 10.

McNeill, Psyche, VI., 1891, 24.

Smith, Ins. N. J. 1890, 409.

Platyphyllum perspicillatum, Uhler, in Harris Ins. Inj. to Veg., 1862, 158. (Note.)

Rathvon, U. S. Ag. Rep., 1862, 382, figs. 19, 20. (Not *Cyrtophyllus perspicillatus*, Fab.)

The true Katydid is readily known by the characters of this genus. The wing covers and wings of living specimens are dark green; the body, pronotum and head lighter, with a tendency to turn yellowish when dried. Harris says the pronotum is "rough like shagreen, and has somewhat the form of a saddle, being curved downward on each side, and rounded and slightly elevated behind and is marked by two slight transverse furrows." The main veins of the wing cover are very prominent with many reticulating branches, giving that organ much the appearance of a leaf. Posterior femora short, slender, and armed on apical half of lower outer carina with about six small spines. The ovipositor is almost as long as the abdomen, cimeter-shaped, sharp-pointed, and with but slight serrations on the lower edge of apical third. Below the curved anal cerci of the male is a spine, resembling in appearance the cerci, which curves beneath the projecting sub-anal plate.

Measurements: Male—Length of body, 30 mm.; of tegmina, 37 mm.; of posterior femora, 21 mm.; of sub-anal spine, 11 mm. Width of tegmina, 18 mm. Female—Length of body, 29 mm.; of tegmina, 36 mm.; of posterior femora, 22 mm.; of ovipositor, 14 mm. Width of tegmina, 16 mm.

The Broad-winged Katydid is found in considerable numbers throughout the State but is much more commonly heard than seen, as it dwells singly or in pairs in the densest foliage which it can find such as the tops of shade trees and the entwining vines of the grape arbor. It is more domestic in its habits than any other species of the "Katydid" group, frequenting, for the most part, the shrubbery of yards and orchards and the trees along fence rows, being seldom, if ever, heard in extensive wooded tracts. Its note is the loudest made by any member of the family, the male having the musical organ larger and better developed than in any other. The call is almost always begun soon after dusk with a single note uttered at intervals of about five seconds for a half dozen or

more times. This preliminary note gives the listener the impression that the musician is tuning his instrument, preparatory to the well known double call which is soon begun and kept up almost continuously from dark till dawn.

Of this call Mr. Scudder, says: "The note, which sounds like *xr*, has a shocking lack of melody: the poets who have sung its praises must have heard it at the distance that lends enchantment. In close proximity the sound is excessively rasping and grating, louder and hoarser than I have heard from any other of the Locustarians in America or in Europe, and the Locustarians are the noisiest of all Orthoptera. Since these creatures are abundant wherever they occur, the noise produced by them, on an evening specially favorable to their song, is most discordant. Usually the notes are two in number, rapidly repeated at short intervals. Perhaps nine out of ten will ordinarily give this number; but occasionally a stubborn insect persists in sounding the triple note—('Katy-she-did'); and as Katydids appear desirous of defiantly answering their neighbors in the same measure, the proximity of a treble-voiced songster demoralizes a whole neighborhood, and a curious medley results; notes from some individuals may then be heard all the while, scarcely a moment's time intervening between their stridulations, some nearer, others at a greater distance; so that the air is filled by these noisy troubadours with an indescribably confused and grating clatter."

According to Riley the eggs are thrust, by means of the sharp ovipositor, into crevices and soft substances, and probably, in a state of nature, into the crevices of loose bark, or into the soft stems of woody plants. They are of a dark slate color, about 6.5x2 mm. in size, very flat, pointed at each end, and with the edges beveled off or emarginate. The song has been heard in Putnam county as early as August 5th, and a single female was captured in Lake county on October 15th, so that the species probably exists more than two months in the mature state.

It was to this species that Oliver Wendell Holmes addressed the well known lines:

"I love to hear thine earnest voice
Wherever thou art hid,
Thou testy little dogmatist,
Thou pretty Katydid."

CONOCEPHALINÆ.

Vertex projecting forward and upward in the form of a tubercle or cone, sometimes blunt, sometimes much prolonged. Prosternum toothed

or with two slender spines. Front coxæ (in our genera) with a spine on the outside. Wing covers seldom expanded in the middle, often shorter than the abdomen, and in color either green or brown. Shrilling organ of male well developed, the cross vein prominent, the color light brown, with the central portion transparent (except in the genus *Conocephalus*). The hind legs are usually stout and much thickened at the base as the insects seldom fly, but are active leapers, and very difficult to capture.

The eggs are deposited within the stems or root leaves of grass, the pith of twigs, or sometimes in the turnip-shaped galls so common on certain species of willow. The ovipositor being thus used as a piercer, has in time developed into a slender and sharp pointed instrument which is but little curved and is frequently of excessive length, in some species being over twice as long as the remainder of the body.

To this sub-family belong those slender-bodied green grasshoppers, with long, tapering antennæ which are so common in summer and early autumn in damp meadows and prairies and along the margins of streams, ditches and ponds. They are mostly terrestrial in their habits, but one or two of the larger ones ever being found in trees.

The color of their bodies corresponds closely to that of the stems and leaves of the sedges and grasses among which they dwell, and so protects them from the sight of the few birds which frequent a like locality. Their songs, produced in the same manner as those of their larger cousins, the katydids, are as frequent by day as by night, but are usually soft and low in comparison with those of the former. Their day songs differs from that of the night, and, says Scudder, "It is curious to observe these little creatures suddenly changing from the day to the night song at the mere passing of a cloud and returning to the old note when the sky is clear. By imitating the two songs in the daytime the grasshoppers can be made to represent either at will; at night they have but one note."^{*}

Twenty-one species of this sub-family, representing three genera, are known to occur in the state.

KEY TO GENERA OF CONOCEPHALINÆ.

- a. Vertex produced forwards into a long sharp cone; stridulating organ of male green and opaque . . V. *CONOCEPHALUS*.
- aa. Vertex terminating in a rounded tubercle which is hollowed out on the sides; stridulating organ of male light brown and partly transparent.

^{*}American Naturalist, II., 1868, 116.

- b.* Prosternal spines very short; ovipositor slender,
straight, or very nearly so; insect small . . . VI. *XIPHIIDUM*.
- bb.* Prosternal spines long and slender; ovipositor
stout, usually upcurved; insect large . . VII. *ORCHELINUM*.

V. *CONOCEPHALUS*, Thunbergh (1815.)

The Cone-headed Grasshoppers.

The members of this genus are readily known by having the vertex prolonged forward and upward into a cone which much exceeds in length the first segment of the antennæ. Face very oblique. Eyes subrotund, rather prominent. Spines of pronotum long and slender. Wing covers long, narrow, rounded at the end, much exceeding the abdomen and slightly exceeding the wings in all our species. The stridulating organ of the male is opaque and of a coarse texture in the left wing cover, but transparent at the center of the right. Hind femora of moderate length, rather slender, the insects often using the wings as locomotors. Ovipositor rather narrow, nearly straight, oftentimes of excessive length; the eggs of those species in which the oviposition has been noted, being deposited between the stem and the root leaves of plants. Anal plates of male not produced; the cerci much swollen, recurved and toothed.

Although these insects are said to be rather common by those writers who have prepared lists of Orthoptera from other States, yet in Central and Western Indiana they are the least abundant of all the *Locustida*, five years' collecting having yielded less than twenty specimens. In the northern part of the State, however, they appear to be much more common. Of the habits of the species found in Illinois, McNeill has written: "All the species of *Conocephalus* seem to possess more intelligence than is usual in Orthoptera, and they are about the most difficult of the order to approach. In escaping they usually slip or fall into the grass instead of jumping or flying; but they seem to fully understand that they are very well protected by their color and form. If approached very cautiously they often remain quite still upon the stem of grass upon which you have surprised them with the usually well founded expectation that you will not be able to distinguish them from the green herbage around. If they think it worth while to make some active movement to escape they will frequently slip around on the other side of the stem and walk down the stem to the ground or off upon another plant. Unlike most Orthoptera they do not use their front legs in holding to the mouth

the thing upon which they feed. Instead of biting they seem to wrench or tear away pieces from the stems or leaves."²

The genus is a large one, 101 species being included by Redtenbacher in his monograph. About one dozen are known to occur in the Eastern United States, and four have, up to the present, been taken in Indiana.

- a. Cone of vertex slender, about 3.5 mm. in length, and with either the margin or lower face black.
- b. A black line on each margin of cone extending from the apex half way or more to base; inner, lower carina of posterior femora with four or five minute spines.

10. CONOCEPHALUS ENSIGER, Harris. The Sword-bearer.

Conoccephalus ensiger, Harris, Ins. Inj. to Veg., 1862, 163, fig. 79.

Scudder, Bost. Jour. Nat. Hist., VII., 1862, 449.

Id., Dist. Ins. in New Hamp., 1874, 367. (Note of to music.)

Id., Am. Ency., Ed. 1881, VIII., 170, fig. —.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 72. (Note of to music.)

Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 445.

Smith, Orthop. of Maine, 1868, 145.

Riley, Stand. Nat. Hist., II., 1884, 187, fig. 263.

Comstock, Int. to Ent., I., 1888, 115.

Fernald, Orth. N. Eng., 1888, 22.

Wheeler, Insect Life, II., 1890, 224.

McNeill, Psyche, VI., 1891, 23.

Smith, Ins. of N. Jersey, 1890, 410.

Id., Bull. Ag. Coll. Ex. Stat. N. Jer., No. 90, 1892, 31, pl. II.

Redtenbacher, Monogr. der Conoceph., 1891, 67, 89.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

A slender-bodied species, the general color of which is grass green, the body and face paler; the posterior tibiae and tip of ovipositor infuscated. Lateral carinae of pronotum sometimes with a faint yellow line, more plainly visible in the dried specimens. Tegmina very long and slender. Cone of vertex with a small tooth projecting downward from the front of its base. Ovipositor of excessive length, straight, the apex pointed.

²Psyche, VI., 23.

Measurements: Male—Length of body, 26 mm.; of tegmina, 42 mm.; of posterior femora, 21 mm. Female—Length of body, 28 mm.; of tegmina 47 mm.; of posterior femora, 23 mm.; of cone of vertex 3.25 mm.; of pronotum, 7.5 mm.; of ovipositor, 31 mm.

This is probably the most widely distributed species occurring in the Eastern United States, having been recorded from Maine to Nebraska. It is the most common one occurring in Northern Indiana, where it frequents the tall rank grasses along ditches and the borders of damp prairies. In Vigo and Putnam counties it is scarce, being replaced by *C. nebrascensis*, Bruner.

The female has been recorded as depositing her eggs between the stem and root leaves of *Andropogon*, a genus of tall, coarse grasses which grow in dry, sandy localities. The young, hatched in May, reach maturity about the 5th of August. Mr. Scudder, who has set the note of the male to music, says of the song: "This insect has but a single song and stridulates only by night, or during cloudy weather. It begins its song as soon as the sky is obscured or the sun is near the horizon. It commences with a note like *b r v*, then pauses an instant and immediately emits a rapid succession of sounds like *c h w i* at the rate of about five per second, and continues them for an unlimited time. Another writer likens its note to the syllable '*ik-ik-ik*,' as if sharpening a saw, enlivening low bushes, and particularly the corn patch, as it seems to especially delight in perching near the top of a cornstalk and there giving forth its rather impulsive song."

bb. Cone of the vertex entirely black beneath; posterior femora armed on both of the lower carinae with a number of plainly visible spines.

11. CONOCEPHALUS NEBRASCENSIS, Bruner.

Conocephalus nebrascensis, Bruner, Canadian Ent., XXIII., 1891, 72.

McNeill, Psyche, VI., 1891, 23.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 72.

A heavier bodied and shorter winged species than the preceding. The cone of the vertex projecting upward more strongly and with the apical half more tapering than in *ensiger*; the basal tooth quite prominent. "Anal cerci of male stout, with strong internal hooks. Ovipositor long and slender, lanceolate, a little curved upwards and extending about one-fourth of an inch beyond the closed tegmina."

"General colour bright grass green (rarely a yellowish brown or tan) with narrow, yellowish lines along the lateral carinae of the pronotum. Posterior tibiae together with all the feet more or less infuscated."—Bruner.

Measurements: Male—Length of body, 28 mm.; of tegmina, 37 mm.; of pronotum, 8 mm.; of cone of vertex, 3.5 mm.; of posterior femora, 21 mm. Female—Length of body, 33 mm.; of tegmina, 42 mm.; of posterior femora, 23 mm.; of ovipositor, 29 mm.

The above measurements are very nearly the same as those given by Mr. Bruner in the original description of the species, and are the average of a half dozen specimens in my collection. I have one female, however, which is so much larger that at first I was inclined to think it a different species, but the color and structure, except the measurements, agree in every particular with those given above of *nebrascensis*. The following are the measurements of the specimen in question:

Length of body, 36 mm.; of cone, 4.5 mm.; of tegmina, 49 mm.; of posterior femora, 30 mm.; of ovipositor, 39 mm.

This species has not before been recorded east of Illinois, but in Central Indiana it is the most common of the three species occurring there. A number of specimens have been taken in Putnam county by Mr. Riley and in Vigo and Fulton counties by myself. When approached it often attempts to escape by burrowing beneath the fallen grass. It frequents the same localities as *C. ensiger* and is very liable to be mistaken for that species by the casual observer, but may at once be distinguished by the characters given above.

aa. Cone of vertex rather stout, less than 3 mm. in length, devoid of black markings.

c. Lateral carinae of pronotum with a yellow line; wing covers with irregularly distributed black dots; ovipositor exceeding 25 mm. in length.

12. CONOCEPHALUS ROBUSTUS, Scudder.

Conocephalus robustus, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 449.

Id., Proc. Bost. Soc. Nat. Hist., XI., 1868, 7.

(Song of.)

Id., Am. Naturalist, II., 1868, 117. (Song of.)

Id., Distb. Ins. in N. Hamp., 1874, 367. (Song of.)

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 72. (Song of.)

Riley, Stand. Nat. History., II., 1884, 187.

Comstock, Int. to Ent., I., 1888, 115.

Fernald, Orth. N. Eng., 1888, 23.

McNeill, Psyche, VI., 1891, 23.

Smith, Ins. N. Jer., 1890, 410.

Redtenbacher, Monog. der Conoceph., 1891, 89.
Pl. III., fig. 36.

A larger and thicker bodied species than either of the preceding; and the wing covers broader. Cone of the vertex more like that of *C. ensiger* but shorter, with the apex more obtuse; the frontal basal spine distinct but blunt. Posterior femora armed beneath on both carinæ with a number of rather weak spines. Wings of male equalling the tegmina in length, in the female a little shorter. Ovipositor shorter than in either of the above species. General color either pea-green or dirty brown* or a mixture of both. The cone rarely with a black spot at apex, its sides often with a narrow yellowish line.

Measurements: Male—Length of body, 30 mm.; of tegmina, 44 mm.; of hind femora, 23 mm.; of pronotum, 8 mm.; of cone, 2 mm. Female—Length of body, 31 mm.; of tegmina, 48 mm.; of hind femora, 26 mm.; of ovipositor, 26 mm.

This species seems to be an inhabitant of sandy districts and occurs only along the Atlantic sea coast and the shores of the Great Lakes. In Indiana it has been noted only in Lake county, where Prof. E. E. Slick found it quite frequently along the shore of Lake Michigan during September and October. Of the specimens sent to me—a half dozen males—he wrote: They were caught off of trees, in the dusk of the evening, as they were singing. They sang ("whetted") continuously for ten minutes or longer while I watched them.

Mr. Scudder thus describes the note as heard in New England: "Robustus is exceedingly noisy and sings equally, and I believe similarly, by day and night. The song resembles that of the harvest fly, *Cicada canicularis*. It often lasts for many minutes, and seems, at a distance, to be quite uniform; on a nearer approach one can hear it swelling and decreasing in volume * * * and it is accompanied by a buzzing sound, quite audible near at hand, which resembles the humming of a bee or the droning of a bagpipe."

**C. ensiger* is said also to be thus dimorphic in coloration, but all that I have seen from this state are of the green variety.

- c. Lateral carinae of pronotum without trace of yellow; wing covers a bright, grass green, immaculate; ovipositor less than 20 mm. in length.

13. *CONOCEPHALUS PALUSTRIS*, Blatchley.

Conocephalus palustris, Blatchley, *Canad. Ent. XXV.*, 1893, 89.

A small but comparatively heavy-bodied species, having the cone of the vertex devoid of black markings and without a basal tooth; ovipositor very short and broad; posterior femora armed beneath on both carinae.

Cone of the vertex short and stout, the tip round, the deflexed front with a dull median carina. Pronotum short, broad, the posterior margin regularly rounded, the lateral carinae well defined, the entire surface thickly and rather deeply punctate. Tegmina long and rather narrow, regularly rounded to the apex; of a more delicate texture than in either *C. ensiger*, Harris, or *C. robustus*, Scudder. Fore and middle femora with two short spines on the apical third of the lower outer carina. Hind legs short, the tibiae but little more than half as long as the closed tegmina; the femora with plainly visible spines on both of the inferior carinae, eight on the outer and six on the inner. Ovipositor a little shorter than the hind tibiae, broadest at a point about two-thirds the distance from the base, thence tapering regularly to a sharp apex.

General color a very bright grass green. Fastigium tipped with dull yellow, which extends half way down the sides. Labrum and apical segments of all the palpi a rose red tinged with violet. Tarsi somewhat infuscated. Antennae and apical third of ovipositor reddish-brown.

Measurements: Female—Length of body, 27 mm.; of fastigium in front of eye, 2.75 mm.; of pronotum, 7 mm.; of tegmina, 37 mm.; of hind femora, 20 mm.; of hind tibiae, 19.5 mm.; of ovipositor, 19 mm.

This handsome species of *Conocephalus* belongs to the same group as *C. robustus* and *C. crepitans*, Scudder, but is smaller and of a more uniform and brighter green than either of those species, besides having shorter legs, ovipositor, etc. It is described from a single female taken October 24, from the fallen grasses on the margins of a large low-land pond in Vigo county. This pond is surrounded on all sides by heavy timber, and its margins have yielded a number of interesting Orthoptera found nowhere else in the county. Among them are *Leptygma marginicollis*, Serv., *Paroryza atlantica*, Scudder, *Anaciphus pulicarius*, Sauss., *Phylloscirtes pulchellus*, Uhler, and *Xiphidium nigroplenum*, Bruner. The first four mentioned are insects of a southern range, and perhaps *C. palustris* will in time be found to be more common southward.

VI. XIPHIUM, Serville (1831).

This genus includes our smallest winged Locustidæ. The vertex projects forward and slightly upward in the form of a rounded tubercle which is hollowed out on the sides for the reception of the basal joint of the antennæ. Face rounded, somewhat oblique. Eyes rather large, sub-globose. Spines of prosternum very short and weak; often mere cone-shaped protuberances. Wing covers narrow, straight, rounded at the end, often varying much in length in the same species, but for the most part shorter than the abdomen. Wings usually a little shorter than the wing covers. Stridulating organ of male well developed, the veins prominent, light brown in color, and with the middle transparent. Hind femora of medium length, stout at base. Ovipositor narrow, straight, or but slightly curved, oftentimes of excessive length. Anal plates of male not prolonged; the cerci usually much swollen, and toothed at base on the inner margin. Eight species are known to occur in the State.

These insects are more variable in color and in the length of wings than those of any other genus of Orthoptera known to me. The variations, however, seem to be abrupt with no intervening forms. There are long-winged and short-winged forms of the same species but none with the wings of medium length; and when a brown form is tinged with green, or *vice versa*, the amount of the different color varies but little. Five of our eight species are thus dimorphic as regards the length of wings, the short-winged individuals, as far as my observation goes, far outnumbering those with the wings fully developed; and at least three of the eight are variable with respect to color.

a. Ovipositor shorter than the body.

b. Ovipositor straight.

c. Wings a little longer than the wing covers; the latter always fully developed.

14. XIPHIUM FASCIATUM, (DeGeer.) The Slender Meadow Grasshopper.

Locusta fasciata, DeGeer, "Mem., III., 1778, 458, Pl. XL., fig. 4."

Xiphidium fasciatum, Burmeister, Handb. der Ent., II., 1839, 708.

Scudder, Boston Jour. Nat. Hist., VII., 1862, 451.

Id., Distr. of Ins. in N. Hamp., 1874, 368.

Id., Rep. U. S. Ent. Com., II., Appen. II., 1880, 23.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 75. (Song of.)

Smith, Orthop. of Maine, 1868, 145.

- Packard, Guide, Stud. Ins., 1883, 567.
 Riley, Stand. Nat. History., II., 1884, 186.
 Bruner, Bull. Washb. Coll. Nat. Hist., I., 1885,
 128.
 Id., Ent. News, III., 1892, 265.
 Comstock, Int. to Ent., I., 1888, 114.
 Fernald, Orth. N. Eng., 1888, 24.
 Smith, Ins. of N. Jer., 1890, 411.
 Id., Bull. 90, Ag. Coll. Exp. Stat. N. Jer., 1892, 31,
 pl. II.
 McNeill, Psyche, VI, 1891, 24.
 Redtenbacher, Monog. der Conoceph., 1891, 192,
 pl. IV., fig. 82.
 Osborne, Proc. Ia. Acad. Sci., I., 1892, 118.

One of the most slender bodied species belonging to our fauna, and the only one whose wings are never shorter than the body. Posterior femora reaching to or slightly beyond the tip of tegmina in the female, distinctly shorter in the male. Face, sides of pronotum and abdomen, and basal portion of ovipositor green; tegmina and apical third of ovipositor light reddish brown; upper side of abdomen, and stripe on occiput and disk of pronotum darker brown; legs green, brownish on the knees and tarsi.

Measurements: Male—Length of body, 13.5 mm.; of tegmina, 17.5 mm.; of hind femora, 11.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 14 mm.; of tegmina, 16 mm.; of hind femora, 13 mm.; of ovipositor, 8 mm.

Abundant everywhere in timothy and clover meadows and especially so about small streams in low ground, blue-grass pastures. One of the first of the Locustidae to reach maturity, specimens having been taken in Vigo county as early as July 5th. The note of the male is very faint—a kind of *rr r-r-r* long drawn out.

Fasciatum has, perhaps, the widest distribution of any of our American Locustidae, its range, according to Redtenbacher, being from British America to Buenos Ayres, S. A.

The *Orchelimum gracile* of Harris, usually quoted as a synonym of *X. fasciatum*, has been shown by Bruner (Ent. News, *loc. cit.*) to be a distinct and valid species.

cc. Wings shorter than the wing covers; the latter variable in length.

15. *XIPHIDIUM BREVIPENNE*, Scudder.*Xiphidium brevipennis*, Scudder, Boston Jour. Nat. Hist., VII., 1862, 451.*Xiphidium brevipenne*, Id., Dist. Ins. in N. Hamp., 1874, 368.

Id., Sec. Rep. U. S. Ent. Comm., 1880 Appen., II., 23.

Smith, Orth. of Maine, 1868, 145.

Riley, Stand. Nat. Hist., II., 1884, 186.

Bruner, Bull. Washb. Coll. Lab. Nat. Hist., 1885, I., 128.

Comstock, Int. Ent., I., 1888, 114.

Fernald, Orth. N. Eng., 1888, 24.

Smith, Ins. of N. Jer., 1890, 411.

Id., Bull. 90, Ag. Coll. Exp. Stat. N. Jer., 1892, 31, pl. II.

McNeill, Psyche, VI., 1891, 24.

Redtenbacher, Monog. der Conoceph., 1891, 206, pl. IV., fig. 91.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Blatchley, Can. Ent., XXIV., 1892, 26.

A little shorter and thicker bodied species than *X. fasciatum*. Posterior femora rather short and stout, unarmed beneath, or rarely with one to four minute spines. Cerci of male swollen, the apex strongly compressed and obtuse, armed below the middle with a rather flat, sharp-pointed tooth.

General color light reddish brown; the face and sides of pronotum usually green; stripe on occiput and disk of pronotum a very dark brown, margined on each side with a narrow yellow line; ovipositor reddish brown throughout.

Measurements: Male—Length of body, 12 mm.; of tegmina, 8 mm.; of posterior femora, 11.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 13 mm.; of tegmina, 7.5 mm.; of posterior femora, 11 mm.; of pronotum, 3 mm.; of ovipositor, 9–10 mm.

This is also an abundant species throughout the State, frequenting the same localities as *fasciatum* and reaching maturity about a fortnight later. Long-winged forms of it occasionally occur, but in Indiana they are very scarce, but one or two having come under my notice. Of the variations in the length of the wing covers of it and allied species Prof. Bruner has well said: "That in the genera *Xiphidium* and *Orchelimum* wing length is

a character not to be relied upon as specific or even varietal difference* ; ” yet Redtenbacher in his *Monographie der Conocephaliden* has separated a number of his species by this character alone, and I can find no mention in his work of the fact that such a variation exists.

bb. Ovipositor a little curved ; tegmina constant in length, covering about two-thirds of the abdomen in the male ; shorter in the female.

16. *XIPHIDIUM NEMORALE*, Scudder.

Xiphidium nemorale, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 462.

Id., Entom. Notes, IV., 1875, 65.

Id., Cent. Orth., 1879, 15.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 75.

McNeill, Psyche, VI., 1891, 24.

Bruner, Can. Ent., XXIII, 1891, 59.

Xiphidium curtipenne, Redtenbacher, *Monograph der Conoceph.*, 1891, 208.

A rather robust species with the general color a dark, greenish brown ; tegmina light reddish brown with the front or lower area fuscous. Dorsal stripe of occiput and pronotum not contrasting so strongly with the general color as in the preceding species, margined with a narrow yellow line on each side. All the femora punctate with reddish dots, the tarsi and tip of hind femora dusky. Tegmina with the veins and cross veins unusually prominent giving them a coarse and scabrous look ; the tympanum of male stout and elevated. Cerci conical, the apex obtuse, but little compressed. Ovipositor as long as the abdomen, the apical half with a gentle but evident upward curve.

Measurements: Male—Length of body, 14 mm. ; of tegmina, 8 mm. ; of hind femora, 12 mm. ; of pronotum, 3.5 m. Female—Length of body, 15 m.m. ; of tegmina, 5.5 mm. ; of hind femora, 13 mm. ; of ovipositor, 9 mm.

Redtenbacher, in his *Monographie*, has evidently described this species as new under the name of *curtipenne*. His specimens were from Missouri.

Nemorale is a very common insect in Vigo and Putnam counties but has not as yet, been taken in the northern part of the State. It reaches maturity about August 15th and from then until after heavy frosts may be found in numbers along the borders of dry, upland woods, fence rows, and

* Canadian Ent., XXIII, 59.

roadsides where it delights to rest on the low shrubs, blackberry bushes, or coarse weeds usually growing in such localities. On the sunny afternoons of mid-autumn it is especially abundant on the lower parts of the rail and board fences, the male uttering his faint and monotonous love call—a sort of *ch-e-e-e-e—ch-e-e-e-e*, continuously repeated—the female but a short distance away, a motionless, patient, and apparently attentive listener. When in *coitu* the male does not mount the back of the female, but, with his body reversed, is dragged about by her, this being the common practice of all the species of *Xiphidium* and *Orchelimum*. *Nemorale* has been recorded only from Nebraska, Iowa, and Illinois and seems to be confined to the northern half of the middle United States.

aa. Ovipositor equal to or longer than the body.

d. Length of posterior femora almost equal to that of ovipositor.

e. Body rather stout; the tegmina always covering more than half the abdomen.

f. Abdomen with the dorsal surface light brown, the sides green, or greenish yellow.

17. *XIPHIDIUM ENSIFERUM*, Scudder.

Xiphidium ensifer, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 451.

Xiphidium ensiforme, Id., Bull. U. S. Geol. and Geog. Surv. Terr., 1876, II., 261.

Xiphidium ensiferum, Id., Sec. Rep. U. S. Ent. Comm., 1880, Appen II., 23.

Riley, Stand. Nat. Hist., II., 1884, 186.

Comstock, Int. to Ent., I., 1888, 114.

Wheeler, Insect Life, II., 1890, 222. (Oviposition of.)

McNeill, Psyche, VI., 1891, 24.

Redtenbacher, Monog. der Conoceph., 1891, 209.

Very similar in general appearance to *X. brevipenne*, Scudder, and may be only a variety of that species. Typical examples are larger with a much longer ovipositor. The general color is also more of a green than in *brevipenne*; the face, sides of pronotum and abdomen, and the four anterior femora being of that hue. The tegmina and wings are light, reddish brown, as are also the tibiae and ovipositor; the latter becoming a deeper brown towards the apex. Cerci of male rather stout, with the apical half curved slightly outward and depressed. Ovipositor slender, straight.

Measurements: Male—Length of body, 13.5 mm.; of tegmina, 9 mm.; of hind femora, 13 mm.; of pronotum, 3.5 mm. Female—Length of body, 14.5 mm.; of tegmina, 8.5 mm.; of hind femora, 14 mm.; of ovipositor, 15 mm.

Although found in Indiana wherever collections have been made, this species appears to be less common than either *fasciatum* or *brevipenne*. It differs from them also in the manner of oviposition, as, instead of depositing its eggs in the stems of grasses, it seeks the turnip-shaped galls so common on certain species of *Salix* (willow) and oviposits between their scales. The gall is not formed by the Locustid, but by a Dipterous insect belonging to the family of *Cecidomyida*. Although I have never seen the eggs deposited I have on a number of occasions found them within the galls, but did not know to what insect they belonged until Mr. Wheeler published (*loc. cit.*) his excellent account of the oviposition of this species. From that I quote as follows: "On September 8th I observed a female in the act of ovipositor. She was perched with her head turned toward the apex of the gall. Slowly and sedately she thrust her sword-shaped ovipositor down between the leaves, and, after depositing an egg, as slowly withdrew the organ in order to recommence the same operation, after taking a few steps to one side of where she had been at work. She soon observed me and slipped away without completing her task. The number of eggs found in a gall varies considerably. Sometimes but two or three will be found, more frequently from fifty to one hundred. In one small gall I counted one hundred and seventy." The egg is cream colored, very thin, elongate oval in outline, and measures 4x1 mm.* The young emerge about the middle of May and reach maturity about August 10th. Long-winged forms of this species are occasionally met with.

On October 21 a pupa was taken which had a white hair worm (*Gordius*) 8½ inches long in its abdomen.

Ensiferum was first described from Illinois, and, as yet, has not been recorded east of the Alleghany Mountains.

ff. Abdomen with the dorsal surface a fuscous brown, the sides shining black.

*Mr. B. D. Walsh, in the Proc. Ent. Soc. Phil., III., 1864, 232, recorded the finding, on numerous occasions, of the eggs of an *Orchelimum* in the turnip-shaped galls of *Salix cordata*. Their shape and proportional dimensions, as given by him, differ much from those of *X. ensiferum*, as they were cylindrical, .16 to .17 of an inch long, and seven times as long as wide.

18. *XIPHIDIUM NIGROPLEURUM*, Bruner. The Black-sided Grasshopper.

Xiphidium nigropleurum, Bruner, Canad. Entom., XXIII., 1891, 58.

Osborne, Proc. Ia. Acad. Sci., I., 1862, 118.

Blatchley, Canad. Ent., XXV., 1893, 90.

A medium sized, rather robust species, easily distinguished from all others of the genus by its peculiar coloration. In Indiana dimorphic forms occur; one having the pronotum, tegmina and legs bright grass green, the other with these parts brownish yellow, the green wholly absent. Both forms have the stripe on the occiput and the sides of the abdomen shining black; the former narrowing in front to the width of the tubercle, and bordered on each side with yellowish white. In the green forms the usual brown stripe on the disk of pronotum is but faintly defined, in the other it is very evident.

"The tegmina are usually abbreviated, reaching only four-fifths of the length of the abdomen, but an occasional specimen is to be found in which the wings are fully developed and then reach to the extremity of the ovipositor in the female. Ovipositor straight, quite broad and heavy. Male cerci of medium length, rather stout, tapering gently toward the apex, and with a strong sub-basal tooth."—Bruner, (*loc. cit.*)

Measurements: Male—Length of body, 14 mm.; of tegmina, 9 mm.; of hind femora, 13.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 15 mm.; of tegmina, 8.5 mm.; of hind femora, 14 mm.; of ovipositor, 16 mm.

In Indiana this handsome insect is known to occur in the two widely separated counties of Fulton and Vigo, but in restricted localities and small numbers, as far as noted, in each. In Fulton county it was found only in a broad, shallow ditch by the side of a railway and near the border of a large tamarack swamp, where it inhabited a space not more than twenty feet square, which contained several dead willow branches, surrounded by a dense growth of sedge and *Polygonum*. Here, on August 26th, four females were taken and on September 24th two males and two females. These were all that were seen, although a careful search was made over a wide area in every direction for others. The most of those secured were taken by clasping the hand about the slender willow branches which were raised a few inches above the ground, on the under side of which the insects took refuge when pursued. A single male taken from the margin of the large pond mentioned under *Conocephalus palustris*, is the only specimen as yet seen in Vigo county. The species has been

noted before only in Iowa and Nebraska, but probably occurs in suitable localities throughout northern Illinois and northwestern Indiana. Of its habits in Nebraska, Bruner has written as follows: "It is quite plentiful among the rank vegetation on low moist ground, and is especially common in wet places where the "cut grass" (*Leersia oryzoides*, Swartz) grows. The supposition is that this grass offers a better place than usual for the deposition of its eggs, which are deposited between the leaves and stems of grass. Grape vines and other creeping plants which form matted clusters that afford shelter from the noonday sun and the bright light of day are favorite haunts of this and other species of our nocturnal grasshoppers and a few of the arboreal crickets."

Since writing the above I have received a pair of this species from Mr. A. P. Morse, Wellesly, Mass., which were labelled "Ithaca, N. Y.," thus extending eastward its known habitat by more than 700 miles.

ee. Body very slender; the tegmina exceedingly short, pad-like, covering only one-third of abdomen.

19. *XIPHIDIUM MODESTUM*, Bruner.

Xiphidium modestum, Bruner, Can. Ent., XXIII., 1891, 56.

This is the smallest and most slender-bodied Locustid found in the state. It is a dull, reddish brown in color, except the stripe on the occiput and disk of pronotum, which is a dark, chocolate-brown, the two colors being separated by a rather wide yellowish line which in living specimens is very distinct.

The cone of vertex is short and rather narrow. Tegmina, especially those of the female, very short and obtusely rounded. Cerci of male elongate, tapering, a little curved outward and armed with a rather long sub-basal tooth. Ovipositor equalling the body in length, very slender and tapering, with its apical half slightly upcurved.

Measurements: Male—Length of body, 10 mm.; of tegmina, 3 mm.; of hind femora, 9 mm.; of pronotum, 3 mm. Female—Length of body, 11 mm.; of tegmina, 2.5 mm.; of hind femora, 9.5 mm.; of ovipositor, 11 mm.

As yet noted only at one point in the state, namely, the border of a raw prairie near Heckland, Vigo county, where it was found in small numbers on October, 21st. It appears to be less active than any other *Xiphidium*, leaping a shorter distance when disturbed, and frequenting the surface of the ground rather than the stems of the tall prairie grasses among which it makes it home. It will probably be found throughout the prai-

rie region of the state, but has not before been recorded east of the Mississippi river, although it is said by Bruner to be very plentiful in Nebraska, Iowa and Kansas.

dd. Posterior femora much shorter than the ovipositor; the latter of excessive length.

g. The common form with the tegmina very short, less than half the length of the abdomen; the sides of the body green.

20. *XIPHIDIUM STRICTUM*, Scudder.

Xiphidium strictum, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 460.

Id., Entom. Notes, IV., 1875, 63.

Id., Cent. of Orthop., 1879, 13.

Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1885, 128.

McNeill, Psyche, VI., 1891, 24.

Redtenbacher, Monog. der Conoceph., 1891, 205.

This is a species with the body rather slender, of more than average length; constant in color but dimorphic as respects the length of wings, the long winged forms, however, being very scarce. Sides of head and body together with all the femora green. The usual reddish brown stripes on occiput and pronotum narrowly edged with whitish, especially on the fastigium of the vertex. Tegmina reddish brown; in the females exceedingly short and pad like, or well developed and reaching almost to knees; when the former, a little longer than the wings; when the latter, 5 mm. shorter than the wings. In the brachypterous males (the only ones I have seen) the tegmina are somewhat less than half the length of the abdomen. A reddish brown band on dorsal surface of abdomen, darker where it meets the green on sides. Ovipositor pale red, straight, one and a half times the length of the posterior femora. Cerci of male, long, the apical half acuminate, curved slightly inward near the tip.

Measurements: Male—Length of body, 14 mm.; of tegmina, 5.5 mm.; of pronotum, 3.5 mm.; of hind femora, 13.5 mm. Female—Length of body, 17 mm.; of tegmina, short winged form, 3.5 mm.; long winged form, 16 mm.; of hind femora, 15.5 mm.; of ovipositor, 23 mm.

A common species in the prairie country of the western and northern parts of the state, where it frequents, for the most part, dry upland meadows and prairies and reaches maturity about August 5th. An active leaper and tumbler and, like the next species, often striving to escape de-

tection by burrowing beneath fallen weeds and grasses. Its general range is to the west and southwest, it having first been described from Texas, and it has not heretofore been recorded east of Illinois.

gg. The common form with the tegmina covering three-fourths or more of abdomen; sides of body dull, reddish brown.

21. *XIPHIDIUM ATTENUATUM*, Scudder. The Lance-tailed Grasshopper.

Xiphidium attenuatum, Scudder, Trans. Am. Ent. Soc., II., 1869, 305,

(Long winged form.)

Bruner, Canad. Entom., XXIII., 1891, 57.

Id., Entom. News, III., 1892, 265.

Redtenbacher, Monog. der Conoceph., 1891, 191.

(Long winged form.)

Xiphidium scudderi, Blatchley, Canad. Entom., XXIV., 1892, 26. (Short

winged form.)

? *Xiphidium lanceolatum*, Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

A medium sized grasshopper with the sides of head and body dull reddish brown. Vertex, disk of pronotum, and tegmina greenish brown in life, the former with the usual dark brown median stripe. Femora greenish brown, very rarely bright green, the tibiae and tarsi darker. Tegmina and wings either abbreviated or fully developed—when the former, covering about three-fourths of the abdomen, when the latter considerably surpassing its tip in both sexes. Antennae with the basal third reddish, the remainder fuscous, longer than in any other member of the genus belonging to our fauna, measuring 73 mm. in one specimen at hand. Ovipositor also longer than in any other; slender and nearly straight, the apex very acuminate; cerci of male long, broad, with the apical third gently tapering, the basal tooth minute, slender.

Measurements: Male—Length of body, 14 mm.; of pronotum, 3 mm.; of tegmina, short form, 10 mm.; of hind femora, 14.5 mm. Female—Length of body, 16 mm.; of tegmina, 9.5 mm.; of hind femora, 15 mm.; of ovipositor, 27—30 mm.

In Indiana the "Lance-tailed Grasshopper" has, up to the present, been recorded only in Vigo county where it is common about the margins of two large ponds in the Wabash river bottoms, but is found nowhere else. The distance between these two ponds is 15 miles and the one to the south is surrounded on all sides with heavy timber. About its margins on September 5th, 1892, mature specimens of *X. attenuatum* were very plentiful

but no young were seen. On the next day the young in all stages were found at the north pond, which lies in an open prairie region, while but one imago was noted. Ten days later the north pond was again visited and many imagoes secured, although the young were still plentiful.

The difference in time of development at the two ponds is probably due to the surrounding forest which shelters the one to the southward, as about its margins occur the four southern species of Orthoptera mentioned above in the notes on *Conocephalus palustris*, not one of which has been found at the north pond.

The males of *attenuatum* are, as far as my experience goes, the most active leapers among the winged Locustidæ, jumping a half a dozen or more times without pause when flushed, and in the net leaping so rapidly from side to side as to prevent capture with the fingers. The females are evidently handicapped in their leaping powers by the excessive length of the ovipositor, and so more often endeavor to escape by burrowing beneath the dense masses of fallen grass and reed stems which are always found in their accustomed haunts.

I find that the length of the ovipositor among the different species of *Xiphidium* is not at all dependent upon the age of the insect. In *attenuatum* it is almost as long after the third, and fully as long after the fourth moult as it is in the imago; while on August 11th a female of *strictum* was taken with no vestige of tegmina in which the ovipositor measured 18 mm. The eggs of *attenuatum*, as the length of the ovipositor indicates, are laid between the stems and leaves of tall, rank grasses.

Only the short winged form of this species has been noted in Indiana, but Prof. Bruner has taken the long winged form in Nebraska, and Mr. Scudder described it from the latter taken in Illinois; though McNeill makes no mention of the species in his list of Orthoptera from that state. Redtenbacher, in his Monographie, has copied Scudder's description and has separated the species from all others of those from America to which it is closely allied, placing it next to *fasciatum*, with which it has little affinity, by virtue of the wing characters alone.

VII. ORCHELIMUM, Serville (1831).

Locustidæ of medium size, but with a short and stout body. Vertex, face and eyes much as in *Xiphidium*. Spines of the prosternum well developed, cylindrical and slender. Antennæ slender and tapering, usually of excessive length. Wing covers narrow, the apical half often much less in width than the basal, exceeding the abdomen in all of our species;

almost always shorter than the wings. Stridulating organ of the male as in *Xiphidium*, but proportionally larger. Ovipositor stout, broad, with the apical half usually upcurved; when straight the apical third tapers rather abruptly on the under side to a fine point. Anal plates and cerci of males as in *Xiphidium*.

Very close to *Xiphidium*, and by some writers united with that genus. Redtenbacher places it as a sub-genus of *Xiphidium*, separating its members from those of *Xiphidium* proper by the same characters as did Serville. As scientists differ in opinion with respect to what characters are necessary to constitute a genus, and as, at the best, it is but an artificial and arbitrary grouping of species for the sake of convenience, I follow Serville, Scudder and Bruner in separating the two, believing that the prime idea of convenience can thus be better subserved.

As seen above, the larger, heavier body, longer prosternal spines, and shorter and broader falcate ovipositor are the chief distinguishing characters of *Orchelimum*. The wing covers are more uniform in length, and the color, while of slightly different shades of brown or green in the same species according to season and habitat, does not run to the extremes of variation as in *Xiphidium*.

The generic name, *Orchelimum*, the literal meaning of which is "I dance in the meadows," is a most appropriate one, for low, moist meadows everywhere swarm with these insects from July to November; and though waltzes and quadrilles are probably not indulged in, yet the music and song, the wooing and love-making which are the natural accompaniments of those amusements, are ever present, and make the short season of mature life of the participants a seemingly happy one.

Nine species of the genus have been taken by the writer within the State, and probably several others occur which have not as yet been discovered.

- a. Ovipositor with a very evident curve; its length less than 10 mm.
- b. Face without a median brown stripe.
- c. Posterior femora unarmed beneath.
- d. Tegmina broadest at base; the apical third narrower; body robust.
- e. Tegmina and wings sub-equal in length; size, medium.

22. *ORCHELIMUM VULGARE*, Harris. The Common Meadow Grasshopper.
Orchelimum vulgare, Harris, Ins. Inj. to Veg., 1862, 162, fig. 77.

- Scudder, Bost. Jour. Nat. Hist., VII., 1862, 452.
 Id., Proc. Bost. Soc. Nat. Hist., XI., 1868. (Note of set to music.)
 Id., Am. Naturalist, II., 1868, 117. (Note of set to music.)
 Id., Distrib. Ins. in N. Hamp., 1874, 368. (Note of set to music.)
 Id., Rep. Ent. Soc. Ont., XXIII., 1892, 73. (Note of set to music.)
 Rathvon, U. S. Agr. Rep., 1862, 382.
 Smith, Orthop. Maine, 1868, 145.
 Thomas, Geol. Surv. Wyoming, 1870, 269.
 Packard, Guide to Stud. Ins., 1883, 567.
 Riley, Stand. Nat. Hist., II., 1884, 187.
 Bruner, Bull. Washb., Coll. Lab. Nat. Hist., I., 1885, 129.
 Comstock, Int. Entom., I., 1888, 114.
 Smith, Ins. of N. Jersey, 1890, 411.
 Id., Bull. Ag. Coll. Exp. Stat. N. Jer., No. 90, 1892, 5, 22, 31, fig. 13, pl. II.
 McNeill, Psyche, VI., 1891, 25.
 Osborne, Proc. Ia. Acad. Sci., 1892, 118.
Xiphidium vulgare, Fernald, Orth. N. Eng., 1884, 24.
Xiphidium fasciatum, Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 444.
 (Not *X. fasciatum*, DeGeer.)
Xiphidium agile, Redtenbacher, Monog. der Conoceph., 1891, 186. (In part.)

A medium sized, robust species, with the general color green or light reddish brown. Face light green or light brown without fuscous marks. The occiput and disk of pronotum with a reddish brown band, widening on the latter, where it is often, especially in the male, bordered on each side with a darker line. The male (as in most of our species) with two short, black dashes on each wing cover, the four forming the angles of an assumed square, enclosing the tympanum. The legs usually pale brown, the tarsi dusky. Pronotum long, its posterior lobe but slightly, if at all, upturned above the plane of the anterior, its hind margin broadly rounded. Tegmina reaching to or very slightly beyond the apex of hind femora, and equalling or very little shorter than the wings. Cerci of male rather

long, the apex bluntly rounded, a little depressed; sub-basal tooth somewhat flattened, with the tip sharp and decurved.

Measurements: Male—Length of body, 18 mm.; of pronotum, 6 mm.; of tegmina, 21 mm.; of hind femora, 18 mm. Female—Length of body, 19 mm.; of pronotum 6.2 mm.; of tegmina, 21 mm.; of hind femora, 18.5 mm.; of ovipositor, 7.5 mm.

Redtenbacher places *vulgare* as a synonym of DeGeer's *Xiphidium agile*, stating as his reason for so doing that Harris and Scudder have separated the two "on account of small differences in the color and size of the wing covers, as well as in the length of the ovipositor." He may be right in thus combining them, but his relative measurements of *X. agile*, as given, do not agree with specimens of undoubted *vulgare* in my possession. Scudder, who has had ample opportunity to compare the two, says (Bost. Journ. Nat. Hist.) that the pronotum is shorter in *agile* than in *vulgare*. Redtenbacher's measurements of this organ, as well as those of the hind femora, are much less than the average measurements given above. Harris, as well as Burmeister, states that the tegmina of *agile* are 2.5 mm. shorter than the wings, while McNeill, in his description of *O. silvaticum*,* says that *agile* has the hind femora armed beneath. Taking all these facts into consideration, though having no typical example of *agile* for comparison, I have concluded not to follow Redtenbacher but to retain for the species at hand the name *vulgare*, by which it is best known to the entomologists of the United States.

This is probably the most abundant member of the family Locustidae found in Indiana. It begins to reach maturity in the central part of the State about July 20th, and more frequently than any other of our species of *Orchelimum* it is found in upland localities, along fence rows, and in clover and timothy meadows. In early autumn it seems to be very fond of resting on the leaves and stems of the ironweed, *Vernonia fasciculata*, Michx., so common in many blue grass pastures. *Vulgare* seems to be somewhat carnivorous in habit, as on two occasions I have discovered it feeding upon the bodies of small moths which in some way it had managed to capture. The note of the male has been well represented by McNeill as "the familiar zip-zip-zip-zip-ze-e-e-e—the staccato first part being repeated about four times, usually about twice a second; the ze-e-e-e continuing from two or three to twenty or more seconds."

*Psyche, VI., 26.

cc. Tegmina distinctly shorter than wings; size large.

23. ORCHELIMUM GLABERRIMUM, (Burmeister.)

Xiphidium glaberrimum, Burmeister, Handb. der Ent., II., 1838, 707.

Fernald, Orth. N. Eng., 1888, 25.

Redtenbacher, Monog. der Conoceph., 1891, 187.

Orchelimum glaberrimum Scudder, Bost. Journ. Nat. Hist., VII., 1862, 453.

Walsh, Proc. Ent. Soc. Phil., III., 1864, 232.

Riley, Stand. Nat. Hist., II., 1884, 186.

Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1885, 128.

Comstock, Int. to Entom., I., 1888, 114.

Smith, Ins. N. Jer., 1890, 410.

McNeil, Psyche, VI., 1891, 25.

Very close to and perhaps only a larger form of *O. vulgare*. The general color is the same, but the brown line on the disk of pronotum is, in the female, more plainly margined with black, while in the male the black dashes at ends of tympanum are larger and more completely enclose that organ. The tegmina of the male exceed the hind femora by about 4 mm., and are exceeded by the wings about the same distance; those of the female are proportionally a little shorter.

Measurements: Male—Length of body, 22.5 mm.; of pronotum, 6 mm.; of tegmina, 25 mm.; of hind femora, 19 mm. Female—Length of body, 23 mm.; of pronotum, 6.5 mm.; of tegmina, 24 mm.; of hind femora, 19 mm.; of ovipositor, 8.5 mm.

Burmeister's original description of this species is very short and not distinctive. It is as follows: "Verticis et pronoti medio fulvo, nigro-marginato; elytris ab alis dimidia linea superatis. Long. corp., 11'''." Burmeister knew but two species from the United States, and this short description was sufficient for him to distinguish these, but of the twenty or more species now known it is difficult to say just which one he had in mind when he wrote the above. Of the specimens referred to this species I have but three examples. One is from Fulton county, the other two from Vigo. They were taken from tall grass growing near the margin of ponds. Nothing distinctive of their habits is known.

dd. Tegmina of equal width throughout; body slender.

24. ORCHELIMUM CAMPESTRE, Blatchley.

Orchelimum campestre, Blatchley, Canad. Entom., XXV., 1893, 91.

A species of less than medium size, with the wing-covers narrow and of almost equal width throughout, the posterior femora unarmed beneath, and the ovipositor short and narrow.

Cone of the vertex prominent, narrow, rounded at the apex; the sides of the frontal deflexed portion rapidly converging to form a very acute wedge. Wing-covers long, slender, not narrowed in the middle as in *O. vulgare*, *glaberrimum*, etc., tapering slightly on the apical third to a rounded end; their length equalling that of the wings in the male, a little shorter in the female. Posterior femora with the basal half quite stout, the length less than that of the tegmina. Cerci of male slender, cylindrical, somewhat pointed, the apical half curved slightly outwards, the basal tooth short and weak. Ovipositor short, narrow, moderately upcurved, and tapering to a delicate point.

Color.—Tegmina and wings almost uniform transparent olivaceous brown. The usual dark reddish-brown band upon the occiput and disk of pronotum is margined on the latter with two very narrow and darker brown stripes, which extend back to the middle of the posterior lobe of the pronotum. Face, and usually the hind femora, a dirty olive brown; the latter, when dry, with a blackish longitudinal band on the exterior face. In the female the only green on the body is on the lower part of the sides of the pronotum and on the anterior femora. The only male at hand has the posterior femora green, but otherwise is colored like the females. Ovipositor light reddish-brown.

Measurements.—Length of body, male, 17.5 mm.; female, 19 mm.; of pronotum, male, 4.5 mm.; female, 5 mm.; of tegmina, male, 20.5 mm.; female, 24.5 mm.; of antennæ, male, 46 mm.; of posterior femora, male, 17 mm.; female, 17.5 mm.; of ovipositor, 7 mm.

This dull colored grasshopper has been found in small numbers in both Vigo and Fulton counties, in upland prairie meadows, where it frequents the tall grasses, usually in company with *Xiphidium strictum*, Scudder.

It is a smaller and more slender bodied insect than the common *O. vulgare*, Harris, and has a shorter and narrower pronotum and a much smaller ovipositor than that species.

cc. Apical half of posterior femora armed beneath with several small spines.

f. All the tibiæ and tarsi black or dark brown.

25. **ORCHELIMUM NIGRIPES**, Scudder. The Black-legged Grasshopper.

Orchelimum nigripes, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 459.

Id., Entom. Notes, IV., 1875, 62.

Id., Cent. Orthop., 1879, 12.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 73.

Bruner, Bull. Washb., Coll. Lab. Nat. Hist., I., 1885, 128.

McNeill, Psyche, VI., 1891, 25.

Redtenbacher, Monog. der Conoceph., 1891, 188.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 118.

Blatchley, Canad. Ent., XXV., 1893, 93.

Somewhat smaller than *O. vulgare*; the body moderately robust. Pronotum short, the posterior lobe, especially in the male, rather strongly upturned. Tegmina a little shorter than the wings, surpassing slightly the hind femora. The shrilling organ of the male is unusually large and prominent with strong cross veins, and behind it the tegmina taper rapidly on both margins; their shape and the size of the tympanum causing the male to appear somewhat peculiar and much more robust than it really is. Hind femora armed on apical half of lower outer carina with from one to four small spines. Cerci of male slender, tapering, the apex a little obtuse; the sub-basal tooth long, slender and a little curved. Ovipositor rather long, broadest in the middle, tapering to a delicate point. The males vary much in size. General color green or reddish-brown, the former prevailing in the male, the latter in the female. Occiput and disk of pronotum with the usual brown markings. Front and sides of head, and four front femora, reddish yellow. All the tibiae and tarsi, together with the apical third of hind femora, black or dark brown; in one specimen at hand the whole body, except the wing-covers and femora, black.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of tegmina, 21 mm.; of hind femora, 16 mm. Female—Length of body, 19 mm.; of tegmina, 22 mm.; of hind femora, 17 mm.; of ovipositor, 9 mm.

A lowland species, which, in Vigo county, is excessively common from August 1st to October 15th, about the river bottom ponds mentioned above, where it frequents the stems and leaves of the different species of *Polygonum*, or smart weed, growing in the shallow water. A few specimens have been taken in Putnam county, and a single male from the margin of a tamarack swamp at Kewanna, Fulton county, so that it probably occurs

in suitable localities throughout the state. It was first described from Texas and has not before been recorded east of Illinois, though it has been taken by myself at Celina, Ohio. Its song is much more faint than that of *O. vulgare*, and the *z-e-e-e-c* is much less prolonged.

if. The tibiae and tarsi green or reddish-brown.

26. *ORCHELIMUM SILVATICUM*, McNeill.

Orchelimum silvaticum, McNeill, Psyche, VI., February, 1891, 26.

Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 73.

? *Xiphidium spinulosum*, Redtenbacher, Monog. der Conoceph., April, 1891, 189.

A somewhat smaller and less robust species than *O. vulgare*, though the proportional measurements of the two are almost the same. The pronotum is shorter, the tegmina more narrow, and in the female the latter are slightly exceeded by the wings; equalling them or a little shorter in the male. The hind femora reach to or slightly beyond the apex of tegmina and are armed on the lower outer carina with three or four minute spines. The general color is the same as that of *vulgare*, but the blackish stripes on the margin of the brown discal stripe of pronotum are more distinct than in that species.

Measurements: Male—Length of body, 17.5 mm.; of pronotum, 4.5 mm.; of tegmina, 16.5 mm.; of hind femora, 15 mm. Female—Length of body, 17.5 mm.; of tegmina, 17 mm.; of hind femora, 15 mm.; of ovipositor, 8 mm.

I am inclined to believe that Redtenbacher's *Xiphidium spinulosum* is this species. The measurements as given by him are somewhat greater, but otherwise the description agrees. McNeill's name, however, has the priority.

In Indiana this species has, up to the present, been taken only in Vigo county, where it frequents the borders of cultivated fields and open woods, reaching maturity about August 20th. "Its stridulation," says McNeill, "is quite distinct from that of *vulgare*. It consists of the same two elements, but the *zip* is repeated many times very rapidly so as to make almost a continuous sound and the *z-e-e-e-e* is comparatively short and very constant, lasting about eight seconds. The first part of the song lasts from three to five seconds."

bb. Face with a dark reddish-brown stripe down the center.

g. Stripe broadly expanded on the lower half of face. Size medium.

27. ORCHELIMUM CONCINNUM, Scudder.

Orchelimum concinnum, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 452.

Riley, Stand. Nat. Hist., II., 1884, 187.

Comstock, Int. to Entom., I., 1888, 115.

• Smith, Ins. N. Jer., 1890, 410.

McNeill, Psyche, VI., 1891, 25.

Bruner, Canad. Entom., XXIII., 1891, 71.

Xiphidium concinnum, Fernald, Orth. N. Eng., 1888, 25.

Redtenbacher, Monog. der Conoceph., 1891, 188.

A species of medium size with a body less robust than that of *O. vulgare*. General color brownish-green; the female darker. The reddish-brown dorsal stripe of pronotum and occiput passes over the fastigium and down the face broadening above the labrum to cover the whole lower half of face. The tegmina of male brownish-green, a little shorter than the wings; of the female darker and equal to or a little longer than the wings. Pronotum short. Hind femora rather slender, unarmed beneath. Cerci of male with the apex obtuse, a little compressed, the sub-basal tooth rather slender. Ovipositor less curved than that of *O. vulgare* and with a very sharp point.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5.5 mm.; of tegmina, 21 mm.; of hind femora, 16 mm. Female—Length of body, 19 mm.; of tegmina, 20 mm.; of hind femora, 17 mm.; of ovipositor, 8 mm.

A rare species in Vigo and Putnam counties, and as yet not noted in the northern part of the state. It frequents the weedy and grassy margins of marshes and lowland ponds and reaches maturity about August 15th.

gg. Facial stripe of equal width throughout. Size small.

28. ORCHELIMUM INDIANENSE, Blatchley.

Orchelimum indianense, Blatchley, Canad. Entom., XXV., 1893, 90.

A slender-bodied insect, with a dark median streak down the face, and having the posterior femora unarmed beneath. The cone of the vertex is short, rather narrow, with a rounded apex. The tegmina, narrow, tapering, a little shorter than the wings, and of a delicate, almost gauze-like texture. Posterior femora slender, shorter than the closed tegmina. Anal cerci of male of medium size, longer than the subgenital plate, tapering to a dull point; the basal tooth short, with a broad base and a very sharp point. The ovipositor of female of less than average width and length, the apical half with a gentle upward curve.

Color of dried specimens: Tegmina and wings a transparent whitish, tinged with green on the front or lower longitudinal nerves; the cross nervules of the latter darker. Sides of pronotum and abdomen, and all the femora, light green; the tibiae and tarsi of a brownish hue. Face yellowish white, with a dark reddish brown stripe the width of the labrum, starting with the mouth and passing upward to the vertex, where it narrows to the width of that organ; then, broadening on the occiput, it passes back to the front border of the pronotum, where it divides into two narrow streaks, which enclose a whitish area and extend a little beyond the posterior transverse suture, where they taper to an end. Subgenital plate of male yellow. Basal third of ovipositor dark brown, the remainder light reddish-brown.

Measurements: Length of body, male, 17 mm.; female, 17.5 mm.; of pronotum, male and female, 4 mm.; of tegmina, male, 21 mm.; female, 19 mm.; of hind femora, male, 14 mm.; female, 15.5 mm.; of ovipositor, 7.5 mm.

This graceful and prettily marked species was found to be quite common among the rank grasses and sedges growing about the margins of a tamarack swamp near Kewanna, Fulton county. It was first taken on August 26th and again on September 24th, when it appeared more plentiful than before. It is the smallest and most slender of the nine species of the genus so far known to occur in the state, and its markings are very distinct from those of any of the others.

aa. Ovipositor straight or nearly so, the under side of apical third tapering rather abruptly to a fine point; its length 10 or more mm.

h. Posterior femora smooth beneath.

29. *ORCHELIMUM GLADIATOR*, Bruner.

Orchelimum gladiator, Bruner, Canad. Entom., XXIII., 1891, 71.

"In its general structure this species resembles the more robust forms like *O. glaberrimum* and *O. concinnum*. It differs from these however in having shorter legs and antennæ. The posterior femora are rather slender; the cone of the vertex is short and obtuse, with the extreme tip shallowly sulcate; the hind wings are little if any longer than the tegmina, which do not quite reach the tip of the ovipositor.

"Color, pale transparent grass-green throughout, save the usual markings upon the occiput and disk of pronotum, which are dark brown, on the latter composed of two well defined, narrow, slightly diverging lines.

Antennæ rufous, feet and extreme tip of the ovipositor tinged with rufous.

"Measurements: Female—Length of body, 18 mm.; of antennæ, 35 mm.; of pronotum, 4.75 mm.; of tegmina, 19 mm.; of hind femora, 15.5 mm.; of ovipositor, 10 mm."—Bruner.

A single female of this species was taken in Fulton county, August 26th, 1892, from the borders of the tamarack swamp previously noted. It agrees exactly with Mr. Bruner's description, and therefore I have copied the latter verbatim. He described the species from two females taken from the flowers of a prairie golden rod, *Solidago rigida*, L., at West Point, Neb. The male is not as yet known. The species probably occurs in small numbers in low, damp prairies, but as, aside from the long, straight ovipositor, it bears a somewhat general resemblance to *O. vulgare*, it has heretofore been overlooked, or confounded with that common insect.

hh. Posterior femora armed on the lower outer carina with several small spines.

30. ORCHELIMUM BRUNERI, Blatchley.

Orchelimum bruneri, Blatchley, Canad. Entom., XXV., 1893, 92.

A species of medium size and rather slender body with the posterior femora armed beneath, and the ovipositor very broad, nearly straight and of more than average length.

Cone of the vertex narrow, moderately elevated, rounded at apex. Tegmina long and narrow, a little shorter than the wings. Posterior femora rather stout, the apex, when appressed, not quite reaching the tip of ovipositor; armed beneath on the apical half with three or four small spines. Cerci of male stout, acuminate, with the internal tooth prominent.

Ovipositor very similar to that of *O. gladiator*, Bruner, being very long and stout, nearly straight above, and with the under side of apical third sloping rapidly to the acute apex.

Color of dried specimens.—With the exception of the ovipositor, which is a light reddish-brown, and the usual stripe on occiput and disk of pronotum, the whole body is a pale, transparent brownish-green, the green showing plainly only on the lower half of the side of pronotum and on the meso and metapleura. The reddish-brown dorsal stripe of occiput and pronotum is bordered laterally throughout its *entire* length with a very narrow one of much darker brown. When immersed in alcohol the

reddish-brown stripe fades to a yellowish white, leaving the two lateral ones as prominent dark streaks, widest on the central portion of the frontal disk.

Measurements: Length of body, male, 18 mm.; female, 20.5 mm.; of tegmina, male, 21 mm.; female, 25 mm.; of pronotum, male and female, 4.75 mm.; of hind femora, male, 16 mm.; female, 17 mm.; of ovipositor, 10 mm. Described from two males and four females.

This species, the female of which is at once conspicuous by reason of the shape and size of its ovipositor; has been taken in small numbers only in Vigo county,* where it is found during August and September on the leaves and stems of a tall, broad-leaved knot weed, *Polygonum amphibium*, L., which grows luxuriantly in the shallow waters about the margins of two or three large ponds in the Wabash River bottoms. Several other "green grasshoppers," notably among which are *Xiphidium attenuatum*, Scudder, and *Orchelimum nigripes*, Scudder, frequent this plant in immense numbers. Keeping company with them an occasional specimen of *O. bruneri* is seen, but, being an active leaper, it often escapes amidst the dense foliage of the knot weed before its capture can be effected. Its less robust body and longer, armed posterior femora will readily distinguish this species from *O. gladiator*, the only other one which, to my knowledge, has an ovipositor shaped like that of *bruneri*. The latter is named in honor of Prof. Lawrence Bruner, of Lincoln, Neb., one of the leading authorities on N. A. Orthoptera.

STENOPELMATINÆ.

The Indiana members of this subfamily comprise those insects which are commonly called "stone" or "camel crickets," and, so far as known, belong to the single genus *Ceuthophilus*, which is characterized below.

VIII. CEUTHOPHILUS, Scudder (1862).

Wingless Locustidæ of medium or large size with a thick body and arched back. Head large and oval, bent downwards and backwards between the front legs. Antennæ long, slender, cylindrical and tapering to a fine point. Eyes sub-pyriform, the narrow end downwards, placed close to the basal joint of the antennæ. Maxillary palpi long and slender; the apical joint longest, somewhat curved, split on the under side three-fourths of its length, which is nearly equal to that of the two preceding taken together. Pronotum short, not extending over the meso and meta-notum. Prostern-

*Since the above was written this insect has been found to be very plentiful about the margin of Lost Lake, Marshall county, Ind.

um unarmed. Hind femora thick and heavy, turned inwards at the base, channelled beneath, with the margins of the channels either serrate or spined in the males, seldom armed in the females. Ovipositor well developed, nearly straight, a little upturned at the tip, the inner valves usually strongly serrate on the under side of the apical fourth. Cerci of males long, slender, usually very hairy.

These insects are seldom seen except by the professional collector. They are nocturnal in their habits, and during the day hide beneath stones along the margins of small woodland streams, or beneath logs and chunks in damp woods, in which places seldom less than two, nor more than three or four, are found associated together. Being wingless they make no noise, and, like most other silent creatures, are supposed to be deaf, as no trace of an ear drum is visible.

That they are wellnigh omnivorous in their choice of food, I have determined by keeping them in confinement, when they fed upon meat as well as upon pieces of fruit and vegetables, seemingly preferring the latter. The majority of the species evidently reach maturity and deposit their eggs in the late summer or early autumn, as the full grown insects are more common then, but have been taken as late as December 1st. The eggs, which are supposed to be laid in the earth, usually hatch in April, but some are hatched in autumn and the young live over winter (an anomaly among the Locustidæ?) as I have taken them in January and February, and at this writing, December 24th, have one in confinement which has just passed the second moult.

Several of the species inhabit caves and are usually of much larger size, with longer antennæ and smaller compound eyes than those found above ground.

The males of these insects are quite readily separated by the size, number and relative positions of the spines on the under side of the hind femora, as well as by the degree of curvature of the corresponding tibiae. The females, having neither the spined posterior femora nor the curved tibiae, are less readily distinguished by the color and the relative measurements of the different organs. As the two sexes are colored alike and are usually found in close proximity there will be little difficulty in placing the female after determining the male by the keys given below, which mainly pertain to that sex alone.

Seven species have, up to the present, been taken by the writer in Indiana.

- a. Hind tibiae of male with the basal half very distinctly undulated or waved; the hind femora with about 16 small sub-equal spines on each of the lower carinae.

31. *CEUTHOPHILUS MACULATUS*, (Say). The Spotted Wingless Grasshopper.

"*Ephippigera maculata*, Say, (Mss.) Harris Cat. Ins. Mass., 1835, 56."

Rhaphidophora maculata, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 7, 11, 14.

Id., Encyc. Amer. 1881, VIII., 170.

halangopsis maculata, Harris, Ins. Inj. to Veg. 1862, 155, fig. 73.

Ceuthophilus maculatus, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 434.

Id., Distb. Ins. of N. Hamp., 1874, 366.

Smith, Orth. of Maine, 1868, 145.

Packard, Guide Stud. Ins., 1883, 565.

Riley, Stand. Nat. Hist., II., 1884, 184, fig. 259.

Bruner, Bull. Washb. Col. Lab. Nat. Hist., I., 1885, 126.

Fernald, Orth. N. Eng., 1888, 19.

Brunner, Monog. der Stenop. und Gryll., 1888, 307.

Smith, Ins. N. Jers., 1890, 409.

McNeill, Psyche, VI., 1891, 27.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Rhaphidophora lapidicola, Scudder, Proc. Bost. Soc. Nat. Hist., VII., 1861, 7. (In part.)

Thomas, Trans. Ill. St. Ag. Soc., V., 1865, 444.

(Not *Ceuthophilus lapidicolus*, Burmeister.)

General color: Above, sooty brown with the anterior half of each segment dotted with a number of rather large, more or less confluent, pale spots; below pale brown, unspotted. Antennae and legs light, reddish brown; the hind femora barred on the outer surface with numerous short lines of darker brown arranged in parallel rows. Anterior femora short, a little longer than pronotum with one or two spines on the, lower, front carina. Hind femora moderately swollen, the inferior sulcus narrow, with each margin armed, in the male, with about 16 rather small, sub-equal spines; in the female, each margin bears a row of numerous minute teeth. Hind tibiae of male distinctly undulate or waved at base; a little longer than the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 4.5 mm.;

of front femora, 6 mm.; of hind femora, 15 mm.; of hind tibiae, 16 mm.; Female—Length of body, 18 mm.; of pronotum, 6 mm.; of front femora, 6 mm.; of hind femora, 17 mm., of ovipositor, 10 mm.

This insect has a wide range, having been recorded from New England to the Rocky Mountains. In Indiana it is, as far as my observation goes, much less common than some of the other species of the genus, having so far been taken only in Putnam county where, on August 1st, I took several specimens from beneath a log in a deep and damp ravine. It probably occurs sparingly in like situations throughout the state.

- aa. Hind tibiae of male not undulated at base; sometimes with a single, slight curve.
- b. Hind femora but little, if any, shorter than the corresponding tibiae; species living above ground.
- c. Upper sides of body each with a broad, dark reddish-brown stripe.

32. *CEUTHOPHILUS LATENS*, Scudder. The Black-sided Camel Cricket.

Ceuthophilus latens, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 437.

McNeill, Psyche, VI., 1891, 27.

General color, light, reddish brown "with darker streaks upon the hind femora and two broad bands of dark, reddish brown along the whole dorsum, extending half way down the sides, dotted irregularly with brownish yellow spots, most profusely on the abdomen, and separated from one another by a narrow, irregular band of the same color; below yellowish brown; tips of the hind femora dark."

Anterior tibiae one-third longer than the pronotum, with two spines on the outer lower carina. Middle femora bispined on each carina beneath. Hind femora thick and stout, the inferior sulcus wide and deep, the margins unarmed in the female; in the male with three or four minute spines on the apical third of each carina. Hind tibiae straight, a little longer than the femora.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of front femora, 6.5 mm.; of hind femora, 14 mm.; of hind tibiae, 14.5 mm. Female—Length of body, 19 mm.; of hind femora, 14.5 mm.; of hind tibiae, 15 mm.; of ovipositor, 10 mm.

The above description applies to the species as usually found in the State. I have, however, a pair of specimens taken in Putnam county, which, while agreeing fully with the peculiar coloration and relative measurements of *latens*, differ so markedly in size and in the spination

of the femora that I have more than once been inclined to think them a distinct and undescribed species. They have the middle femora armed beneath with 3 spines on each carina; the hind femora of male with 9 spines on the outer carina, the 4 or 5 middle ones of which are very strong and prominent, the inner carina with 11 small and sub-equal spines. The hind tibiae with an evident downward curve at base. The hind femora of the female have 5 small spines on the outer and 11 on the inner carina.

Measurements: Male—Length of body, 22 mm.; of pronotum, 6.5 mm.; of front femora, 9 mm.; hind femora, 19 mm.; of hind tibiae, 21 mm. Female—Length of body, 25 mm.; of pronotum, 7 mm.; of front femora, 9 mm.; of hind femora, 19.5 mm.; of hind tibiae, 20.5 mm.; of ovipositor, 13 mm.

If, as is most likely, these are only greatly developed forms of *latens*, the spining of the femora of these insects varies greatly with the age, and, unless one has adult specimens, it is not therefore a character of as much specific worth as is usually attributed to it.

C. latens is not an uncommon species in Vigo and Putnam counties. It is most commonly found beneath flat stones near the margins of small streams in upland, hilly localities. It reaches maturity in June or July, probably from specimens hatched in spring, though I have taken the young on two different occasions in February. It has been recorded heretofore only from Illinois and the male is herewith described for the first time, Mr. Scudder's description having been based upon a single female.

cc. Sides of body without a dark, reddish brown stripe.

d. Hind femora of male with the inferior sulcus very deep; the outer carina with about 9 spines of unequal length and not equi-distant.

33. *CEUTHOPHILUS UHLERI*, Scudder.

Ceuthophilus uhleri, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 435.

Riley, Stand. Nat. Hist., II., 1884, 184.

Smith, Ins. N. Jer., 1890, 409.

Ceuthophilus lapidicola, Brunner, Monog. der. Stenopel. und Gryllac, 1888, 307. (Not *C. lapidicolus* Burm.)

General color light reddish brown, the meso and meta-notum usually darker. The pronotum rather thickly and irregularly mottled with paler spots; the other segments with the pale spots for the most part in a

transverse row near the hind margin. The legs yellowish brown, the hind femora with the apex a little dusky above and with three longitudinal, and numerous obliquely transverse, dusky bars on the outer face.

The anterior femora but little longer than the pronotum; the lower, front margin armed with from one to four spines. Hind femora of the male of average width but very stout, the lower, outer carina prominent, the inferior sulcus rather narrow and very deep, the sides meeting at an angle above. The spines of the outer carina are arranged in three sets, the basal set containing 4 equi-distant graduated spines the apical one largest; the middle set contains but a single strong spine equal in size to the one before it and separated from it as well as from the first one of the apical set, by a space almost twice as great as between the members of the basal set; the apical set of 4 small sub-equal spines. The inner carina is armed with about 16 small sub-equal spines. The female has the inner carina also armed in like manner with still smaller spines. Hind tibiae of male straight, a little longer than the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 5.2 mm.; of front femora, 6.2 mm.; of hind femora, 16.5 mm.; of hind tibiae, 17 mm.

C. Brunner, in his *Monographie*, has evidently described this species under the name of *C. lapidicola* Burm. At the close of his description he says of *lapidicola*: "Neither the diagnosis of Burmeister nor the description of Scudder are sufficiently exact to recognize the species; for which reason I have designated by this name any new species whatever at hand." In another place he describes under the name *C. uhleri* Scudder, a species having the spines on the outer carina of the hind femora equal in length; whereas Mr. Scudder, in his description of *uhleri* distinctly states that they are "of unequal length, and irregularly arranged."

Specimens of the insect described above were sent to Mr. Scudder, who pronounced my identification correct. In central Indiana *uhleri* is the most common species of *Ceuthophilus*. It is found from July to November beneath rails and logs in rather dry situations. The young have been taken from similar places in December and February, but evidently the larger number of eggs do not hatch until spring.

- dd.* Hind femora of male with the inferior sulcus shallow; the spines of the outer lower carina sub-equal in size and equi-distant from one another.

- c. The sulcus very broad; the spines of the outer carina much larger than those of the inner.

34. *CEUTHOPHILUS LATUSULCUS*, nov. sp.

? *Ceuthophilus uhleri*, Brunner, Monog. der Stenopel. und Gryll., 1888, 308, pl. VII., fig. 33 b. ,

General color, light brownish or clay yellow, irregularly mottled with fuscous, especially on the pronotum and abdomen; the female somewhat darker. The anterior femora much longer than the pronotum with two sub-equal spines near the apex of the lower front carina. The intermediate femora with three spines on each of the lower carinæ. The hind femora not so broad as in the preceding, the outer lower carina much less prominent; the upper half of the exterior face very scabrous, with small projections. The inferior sulcus very broad and shallow, about twice the breadth and one-half the depth of that of *C. uhleri*; the sides not meeting in an angle as there, but the upper surface of the sulcus flat. The outer carina with 8 sub-equal spines borne at equal distances apart on the apical half; the middle two slightly the larger but much less strong than the corresponding one of *C. uhleri*. The inner carina armed with 20 or more very small teeth. The hind tibiæ with a very slight curve just below the base; a little longer than the corresponding femora.

Measurements: Male—Length of body, 15 mm.; of pronotum, 5.1 m.m.; of front femora, 7 mm.; of hind femora, 17.5 mm.; of hind tibiæ, 18.5 mm.

From *C. uhleri*, which it most resembles, this species may at once be known by the longer anterior femora, the much broader and shallower sulcus of the hind femora, as well as by the difference in size and arrangement of the teeth upon the latter. The adult male is larger with longer hind limbs than that of *uhleri*, though the males of both these species are much more robust when mature than those of *maculatus* and *lapidicolus* which have come under my notice.

C. Brunner, in his Monographie, has described a species of *Ceuthophilus* under the name of *uhleri*, Scudder, which may be the same insect as *latusulcus*. As shown above, however, the name of *uhleri* belongs to the preceding species. Brunner's measurement of his so-called *uhleri*, as well as the number of spines on the femora, differ from those given above.

Latusulcus is described from two males and a female taken in Vigo county, August 25, from beneath a log on a sandy hillside.

- ee. The sulcus of average width and depth; the spines of both carinæ small and sub-equal in size.
- f. General color clear reddish brown, mottled with paler; each of the carinæ of the hind femora with about 28 crowded minute spines.

35. *CEUTHOPHILUS LAPIDICOLUS*, (Burmeister.)

Phalangopsis lapidicola, Burmeister, Handb. der Entom. II., 1838, 723.

Raphidophora lapidicola, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 7. (In part.)

Ceuthophilus lapidicolus, Id., Bost. Journ. Nat. Hist., VII., 1862, 435.

Riley, Stand. Nat. Hist., II., 1884, 184.

Smith, Ins. N. Jer., 1890, 409.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Clear reddish-brown, mottled with small pale spots, especially on the abdomen, where the spots have a tendency to arrange themselves in longitudinal rows. The legs paler, the exterior face of the hind femora with the usual darker bars, but not so prominent as in *C. maculatus*. Anterior femora a little longer than pronotum, unarmed beneath. Intermediate femora also unarmed or with a single apical spine on front margin. Hind femora of medium thickness, the inferior sulcus of average width, rather deep; the spines of both carinæ more like the fine teeth of a saw, about 25 in number and crowded on the apical two-thirds of the segment. Hind tibiæ straight, a little shorter than the femora.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of front femora, 6.5 mm.; of hind femora, 18.5 mm.; of hind tibiæ, 16 mm. Female—Length of body, 18.5 mm.; of hind femora, 18 mm.; of ovipositor, 9 mm.

As Brunner has well said it is impossible to distinguish *C. lapidicolus* from Burmeister's description, which was founded upon two female specimens from South Carolina, and undoubtedly many references to it are wrong. If any person is competent to judge as to what *lapidicolus* really is, that person is Mr. Scudder, and I have determined the form described above from specimens bearing that name kindly loaned me by him.

In Indiana, *lapidicolus* is not a common insect, its range probably being more southern. Several specimens have been taken in Putnam county from beneath logs in damp woods.

ff. General color dull yellowish brown, with very numerous paler spots; each of the carinæ of the hind femora with about seven very small and distinct teeth.

36. *CEUTHOPHILUS BREVIPES*, Scudder.

Ceuthophilus brevipes, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 434.

Smith, Orth. of Maine, 1868, 145.

Fernald, Orth. N. Eng., 1888, 19.

Dull yellowish brown, a little darker on the dorsum of the thorax where there is a narrow median line of clay yellow. Very profusely spotted with dirty white spots, especially on the abdomen, and near the apex of hind femora, where they nearly form an annulation.

Front femora a little longer than the pronotum, with a single spine on lower front carina. Hind femora short and stout; the inferior sulcus of average width and depth; each carina armed with about seven very small teeth. Hind tibiæ straight, of the same length as the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 4.5 mm.; of front femora, 5.5 mm.; of hind femora, 12 mm.; of hind tibiæ, 12 mm.

A single male from Vigo county agrees in every respect, except slight differences in measurements, with typical examples from Mr. Scudder's collection. Not before recorded west of New England.

bb. Hind femora distinctly shorter than the corresponding tibiæ; cave inhabiting species.

37. *CEUTHOPHILUS STYGIUS* (Scudder.)

Raphidophora stygius, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 9.

Ceuthophilus stygius, Id., Bost. Jour. Nat. Hist., VII., 1862, 438.

Riley, Stand. Nat. Hist., II., 1884, 184.

Brunner, Monog. der Stenop. und Gryll., 1888, 309.

Pale, reddish-brown, the hind border of each segment with a dark brown band, the pronotum with a similar band on the front margin, and an indistinct, dark median band connecting the two. Face pale with a black dash below each eye, and a shorter median one. Antennæ brownish yellow, paler towards the tip, of excessive length. Front femora, in the specimens at hand, double the length of the pronotum, with three spines on the lower front carina. Middle femora shorter than the anterior with both of the lower carinæ armed with three or four distinct spines. Hind femora rather slender, the lower outer carina prominent; the inferior sulcus narrow and of average depth; both margins armed with num-

erous small spines, those on the outer carina double the size of those on the inner. Hind tibiae straight, much longer than the corresponding femora.

Measurements: Male—Length of body, 26 mm.; of pronotum, 6 mm.; of front femora, 12 mm.; of antennæ, 100 mm.; of hind femora, 23 mm.; of hind tibiae, 27 mm. Female—length of body, 23 mm.; of pronotum, 5.5 mm.; of front femora, 11 mm.; of hind femora, 21 mm.; of hind tibiae, 24 mm.; of ovipositor, 14 mm.

These measurements are much greater than those given by Mr. Scudder, but otherwise the specimens agree with his description in every respect.

Two males and one female of this large and handsome *Ceuthophilus* were taken by Mr. W. P. Hay from a small cave in Crawford county and kindly presented to me. It evidently inhabits only the smaller caves as Mr. Hay saw no specimens in Wyandotte, and Mr. Scudder, in the Proc. Bost. Soc., says of the original types taken in Kentucky: "Though careful search was made in the larger cave, a mile or more in extent, no *Raphidophoræ* were found, but in the remotest corner of the small cave, a few hundred feet only in extent, in a sort of hollow in the rock, not particularly moist, but having only a sort of cave dampness, the *stygia* was found plentifully these were also found exclusively upon the walls. Even the remotest part of the cave is not so gloomy but that some sunlight penetrates it."

DECTICIDINÆ.

In the western states this sub-family is represented by several genera and a large number of species, but east of the Mississippi River there are but two species of a single genus belonging to it, both of which are found in Indiana.

IX. THYREONOTUS, Serville (1839).

These are Locustidæ of large size with the pronotum extending back over the first joint of the abdomen, thus forming a buckler or shield for the back. Face broad, rounded, but slightly oblique. Eyes small, sub-globose. Vertex with a blunt decurved projection between the antennæ which is slightly excavated on the sides. Pronotum truncate in front, rounded behind, flattened above, bent abruptly downwards on the sides. Prosternum armed with two short, blunt spines. Tegmina of the females rudimentary, wholly covered by the pronotum; those of the males fairly well developed, extending in our most common species 5 mm. back of the pronotum. The shrilling organ, which is covered by the pronotum, is

circular, and rather large for the size of the tegmina. Wings very rudimentary or wanting. Hind femora long and rather slender, extending, in our species, beyond the abdomen in both sexes, notably so in the males. Ovipositor as long as the body, very stout at the base, straight.

The "Shield-back Grasshoppers," so called on account of the large protective pronotum, are often quite numerous from April 1st to September in dry upland woods and on sloping hillsides with a southern exposure, but are seldom if ever found in damp localities.

On the first warm days of early spring the young begin to emerge and in suitable places for a month or more are among the most common Orthopterons seen. They are much more active during early life than in the mature state when they crawl rather than leap. In captivity they feed as readily upon animal as upon vegetable food, and in the natural state probably feed upon the dead bodies of such small animals as they can find. The earliest hatched reach maturity in Central Indiana about the middle of July, and may then often be found resting on the leaves and stems of low shrubs and weeds, but seldom climb over two or three feet from the ground. The adults are far less numerous than the young, the vast majority of the latter probably falling a prey to the many ground frequenting sparrows and other birds, as they do not hide by day as do the members of the preceding genus.

- a. Front margin of pronotum much narrowed, but little more than half as wide as hind margin; the latter broadly rounded.

38. *THYREONOTUS PACHYMERUS*, (Burmeister.)

Decticus pachymerus, Burmeister, Handb. der Entom., II., 1838, 712.

Thyreonotus pachymerus, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 453.

Comstock, Int. Ent., I., 1888, 118, fig. 106.

Fernald, Orth. N. Eng., 1888, 26.

Smith, Ins. N. Jer., 1890, 411.

McNeill, Psyche, VI., 1891, 24.

Osborne, Proc. Ia. Acad. Sci., 1892, 119.

Davis, Canad. Entom., XXV., 108 (Song. of).

Color: Male—Grayish or fuscous brown; the sides of pronotum and tegmina black, the former often shining; a narrow, curved yellow line above the posterior lateral angle of pronotum; the exposed dorsal field of tegmina light brown; the femora with numerous minute pale spots. Female—Usually reddish-brown throughout except the yellow line on side of pronotum which is bordered above with a dash of black.

The lateral carinae of pronotum are much sharper in this species than in the next; the pronotum itself is a little longer, and appears more so than it really is on account of the broadly rounded posterior lobe. The latter has in the female a faint median carina which is absent in *dorsalis*. The hind femora, as well as the ovipositor, are a little shorter than in that species, and the apex of the ovipositor is more bluntly rounded from above.

Measurements: Male—Length of body, 20 mm.; of pronotum, 10 mm.; of hind femora, 16 mm. Female—Length of body, 22 mm.; of pronotum, 9 mm.; of hind femora, 18 mm.; of ovipositor 17 mm.

Pachymerus is, in Indiana, by far the more common of the two species known to occur. So far it has been noted only in Putnam and Vigo counties, but undoubtedly is to be found throughout the State, frequenting the localities mentioned above under the generic description. In a pleasing account of the note and habits of the species, Mr. W. T. Davis says as follows: "Its song much resembles that of *Orchelimum vulgare*, with the preliminary *zip, zip*, omitted. It is a continuous *z-e-e-e*, with an occasional short *ik*, caused by the insect getting its wing covers ready for action after a period of silence. * * * * Starting with raspberries, one kept in captivity had the rest of the fruits in their season, including watermelon, of which he showed marked appreciation. If I offered him a raspberry and then gradually drew it away he would follow in the direction of the departing fruit, and would finally eat it from my hand."

aa. Front margin of pronotum but little narrowed, about three-fourths the width of the hind margin, the latter almost square.

39. *THYREONOTUS DORSALIS*, (Burmeister.)

Decticus dorsalis, Burmeister, Handb. der Entom., II., 1838, 713.

Thyreonotus dorsalis, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 454.

Id., Distb. Ins. N. Hamp., 1874, 370.

Id., Proc. Bost. Soc. Nat. Hist., XIX., 1877, 83.

Id., Ent. Notes, VI., 1878, 24.

Comstock, Int. Ent., I., 1888, 118.

Fernald, Orth. N. Eng., 1888, 26.

Smith, Ins. N. Jer., 1890, 411.

Color: Female—Dull, yellowish brown; the posterior lobe of pronotum, dorsum of abdomen and ovipositor dark brown. A blackish spot on the face below each eye; the sides of the pronotum with obsolete fuscous markings. The chief structural distinctions between this insect and *Pachymerus* are given above under the latter species.

Measurements: Female—Length of body, 24 mm.; of pronotum, 8.5 mm.; of hind femora, 21 mm.; of ovipositor, 22 mm.

This species is represented in my collection by two females taken in Vigo county, in August, 1891. It has not heretofore been recorded west of the Alleghany Mountains.



The above thirty-nine species comprise all the Locustidæ which, to the present knowledge of the writer, inhabit Indiana. Others undoubtedly occur, especially in the southern half, and throughout the prairie region of the northwestern part, where no collecting has been done. The present paper will, perhaps, aid in the identification of the more common kinds of this much neglected group of insects; but collectors throughout the state should be on the lookout especially for the following twelve species whose known range implies that they are probably inhabitants of Indiana; and when the careful and systematic biological survey of the state, now instituted, has been completed, a number of them will no doubt have been added to our known insect-fauna:

1. *Scudderia pistillata*, Brunner.

Should be looked for in the northern half of the state. Resembles *furcata*, but has much wider tegmina. Ranges from New Jersey to Nebraska.

2. *Amblycorypha scudderi*, Bruner.

Resembles *oblongifolia*, but is smaller, with comparatively shorter hind legs, and with apex of ovipositor more strongly serrate. Common in Eastern Nebraska.

3. *Microcentrum retinervis*, (Burmeister.)

(See under *M. laurifolium*.) Should be found in Southern Indiana.

4. *Cyrtophyllus perspicillatus*, (Fabricius.)

Has shorter and broader tegmina, more robust legs, and musical organ of male broader than *concaus*. A southern form.

5. *Xiphidium saltans*, Scudder.

Should be found in the prairie region northwest. Resembles *strictum*, but is smaller, with longer tegmina, and shorter ovipositor. Common in Kansas and Nebraska.

6. *Orchelimum delicatum*, Bruner.

A more slender and smaller insect than *vulgare*, with a much

shorter (4 mm.) pronotum, and a much longer (11.5 mm.) and straighter ovipositor. To be looked for northward. Nebraska.

7. *Orchelimum volantum*, McNeill.

Described from Henry county, Illinois. Larger than *vulgare*, with much longer tegmina. Posterior femora armed beneath.

8. *Ceuthophilus ensifer*, Packard.

A cave form described from Kentucky.

9. *Ceuthophilus niger*, Scudder.

Allied to *latens*, but wholly black with a reddish tinge. Hind femora short and unusually slender. Described from Illinois.

10. *Ceuthophilus divergens*, Scudder.

Color of *lapidicolus*, but with five, long spines on each side of hind tibiae, which turn outward at right angles to tibiae. Nebraska, Iowa.

11. *Hadenæcus cavernarum*, Saussure.

A stone cricket, said by Prof. E. D. Cope to inhabit Wyandotte Cave,* but not included in the list proper, as I have seen no specimens.

12. *Undeopsylla nigra*, Scudder.

A stone cricket, recorded from Iowa, Nebraska and Illinois, and therefore to be looked for in Indiana.

BIOLOGICAL LABORATORY, TERRE HAUTE HIGH SCHOOL, May 10, 1893.

THE BLATTIDÆ OF INDIANA BY W. S. BLATCHLEY, Terre Haute, Ind.

The members of the family *Blattidæ*, commonly known as cockroaches, are classed among the *Orthoptera* by reason of their biting mouth parts, and direct or incomplete metamorphosis. From the other families of that order the *Blattidæ* may be known by their depressed, oval form; their nearly horizontal head, which is bent under and almost concealed by the broad prothorax; their slender legs of equal length and size; their five jointed tarsi; and by the absence of either ovipositor or forcipate appendages at the end of the abdomen.

*Cope, in Reps. Ind. Geol. Surv., IV., 1872, 161, and X., 1878, 493, mentions this species under the name of *Raphidophora subterranea*, Scudder—a synonym of *H. cavernarum*.

The rings of the abdomen overlap each other and are capable of great extension and depression so that these insects seem to be pre-eminently fitted for living in the narrow crevices and cracks which they inhabit. The legs are of peculiar structure in that they are long and more or less flattened, thus enabling the cockroaches to run with surprising swiftness, so that the family has been placed by some writers in a separate sub-order, the *Cursoria*, or runners. The wing covers, or tegmina, are leathery, translucent, and, when well developed, overlap when at rest; while the wings never exceed the tegmina in length, and in some cases are rudimentary or even wanting.

From the other Orthoptera the *Blattidae* differ widely in the manner of oviposition, as the eggs are not laid one at a time, but all at once in a peculiar capsule or egg case called an oötheca. These capsules vary in the different species as regards the size, shape, and the number of eggs they contain, but they are all similar in structure. Each one is divided lengthwise by a membranous partition into two cells. Within each of these cells is a single row of cylindrical pouches, somewhat similar in appearance to those of a cartridge belt, and within each pouch is an egg. The female cockroach often runs about for several days with an oötheca protruding from the abdomen, but finally drops it in a suitable place and from it the young, in time, emerge. While this method of oviposition is the one practiced by all the species of common occurrence in the United States, there seem to be exceptions to it, as Dr. C. V. Riley has recently recorded the fact* of an introduced tropical species, *Panchlora viridis*, Burm., being viviparous, the young emerging alive from the body of the parent, and a careful dissection of the latter showing no trace of either eggs or oötheca.

All young cockroaches resemble the parents in form but are wholly wingless, the wings not appearing until after the fifth or last moult. The young are often mistaken for mature individuals by persons who have not made a careful study of the life history of the insects; and those of one or two well known and common forms, have, in the past, even been described or figured as distinct,* wingless species by some of the leading entomologists of the country.

To the paleontologist, interested in tracing back the ancestry of insects, the *Blattidae* become at once a group of surpassing interest, for the oldest known insect, *Palaeoblattina douvillei*, Brong., is a cockroach recently de-

* Insect Life, III., August, 1891, 143.

scribed from the Middle Silurian of France.* Between seventy and eighty fossil species of the family are known, principally from the Mesozoic formations, but some from all above the Middle Silurian. Mr. S. H. Scudder, of Cambridge, Mass., an eminent authority on insect paleontology, says of the cockroach: "Of no other type of insects can it be said that it occurs at every horizon where insects have been found in any numbers; in no group whatever can the changes wrought by time be so carefully and completely studied as here; none other has furnished more important evidence concerning the phylogeny of insects."

Although abundantly represented in individuals, the number of species of *Blattidae* inhabiting the Eastern United States is comparatively few, but twelve or thirteen having been recorded. Of these, seven, representing five different genera, are known by the writer to occur in Indiana. Of the seven, five are indigenous or native species, the other two having been introduced from the Old World.

In the present paper is given a synopsis of the genera occurring in the state, together with the accessible synonymy and a brief popular description of each of the species. Such notes as have come to hand during several years of observation, concerning the life history, distribution, and habits of each species, are also added.

A SYNOPSIS OF THE GENERA OF BLATTIDÆ OCCURRING IN INDIANA.

- a. Sub-anal stylets present in the males.
 - b. Last abdominal sternite of the female divided; length of body more than 22 mm.
 - c. Supra-anal plate either truncate or pointed, and notched or cleft at the end I. PERIPLANETA.
 - cc. Supra-anal plate rounded, entire at the end . . II. ISCHNOPTERA.
 - bb. Last abdominal sternite of the female entire; length of body less than 15 mm. III. TEMNOPTERYX.
- aa. Sub-anal stylets absent in the males; last abdominal sternite of the female entire.
 - d. Body broad, the greatest breadth more than one-half the length; tegmina not reaching the tip of abdomen IV. ECTOBIA.
 - dd. Body narrow, the greatest breadth about one third the length; tegmina reaching to or beyond the tip of the abdomen V. PHYLLODROMIA.

*Scudder, Bulletin U. S. Geog. Survey, No. 31, page 103.

I. PERIPLANETA, Burmeister (1838.)

In this genus the sub-anal stylets of the male are well developed; the last abdominal sternite of the female is divided; the supra-anal plate is either truncate, or pointed and notched at the end, and extends farther back than the sub-genital plate; while the abdomen is wider than the front part of the body. All the femora are armed beneath, on each of the carina, with a single row of slender, curved spines, while the tibiæ bear a double row of much longer ones on each of their margins. Two of the largest species occurring in the state belong in this genus.

1. PERIPLANETA ORIENTALIS, (L.) The Oriental Cockroach. The "Black Beetle."

Periplaneta orientalis, Burmeister, Handbuch der Entom., II., 1838, 504.

Riley, Stand. Nat. Hist., II., 1884, 172, fig. 248.

Id., Insect Life, II., March, 1890, 267.

Comstock, Intr. to Ent., I., 1888, 93.

Fernald, Orth. of N. Eng., 1888, 52, fig. 21. *m*.

Hyatt & Arms, Insecta, 1890, 102, pl. 4, figs. 54, 55.

Kakerlac orientalis, Serville, Hist. Nat. des Orthopteres, 1839, 72.

Blatta orientalis, Harris, Ins. Inj. Veg., 1862, 145, fig. 66. *m*.

Rathvon, U. S. Ag. Rep., 1862, 374, figs. 4, 5.

Stylopyga orientalis, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 416.

Glover, U. S. Ag. Rep., 1874, 132, fig. 4.

Female with rudimentary tegmina which do not exceed 5 mm. in length. Male with the tegmina and wings well developed, the former covering three-fourths of the abdomen, the latter almost as long. General color, dark, mahogany brown, the limbs lighter, the pronotum without a yellow margin. The supra-anal plate of the male is truncate; that of the female is rounded with a shallow notch at the end.

Measurements: Male—Length of body, 22.5 mm.; of tegmina, 14 mm.; of pronotum, 6 mm.; width of pronotum, 8 mm. Female—Length of body, 27.5 mm.; greatest width of body, 13 mm.

The eggs of the Oriental cockroach are sixteen in number, and the large horny capsule or oötheca in which they are packed is carried about by the mother for a week or longer when she drops it in a warm and sheltered place. Along one side of the capsule, which resembles in form and color a diminutive seed of the pawpaw, *Asimina triloba*, Duval, is a seam where the two edges are cemented closely together. When the young are hatched they excrete a liquid which dissolves the cement and

enables them to escape without assistance, leaving their infantile receptacle as entire as it was before they quitted it.

The Oriental cockroach, as its name indicates, is a native of Asia, but has been carried from one country to another by shipping. It delights in filth and darkness, and hence in the holds of vessels, the cellars and basements of tenement houses, and in all damp, dirty places it swarms by thousands, undoubtedly doing much good as a scavenger, but infinitely more harm on account of its omnivorous and insatiable appetite. Like most other members of the family it feeds mainly at night, appearing to detest and avoid the light, as one can readily prove by taking a lighted lamp suddenly into its haunts, when a hurried scrambling will take place towards its daylight retreats, and but a few moments will elapse before the last of the busy marauders will have disappeared.

This is probably the most carnivorous of all our Blattidæ, though, like most others, it is fond of starchy food. It is known to feed upon meat, cheese, woolen clothes, and even old leather, and is said to be especially fond of the festive "bed bug," *Acanthia lectularia* L., which soon disappears from a house infested with the Oriental roach.

In Indiana this species is found in all the larger towns and cities, and is one of the most noisome and disagreeable insects with which certain classes of their inhabitants have to contend.* It seldom occurs in houses in thinly settled localities, and never, as far as my observation goes, beneath the bark of logs and stumps.

2. PERIPLANETA AMERICANA, (L.) The American Cockroach.

Periplaneta americana, Burmeister, Handb. der Entom., II., 1838, 503.

Scudder, Boston Jour. Nat. Hist., VII., 1862, 416.

Riley, Stand. Nat. Hist., II., 1884, 172.

Id., Insect Life, I., 1888, 68; II., 1890, 266.

Fernald. Orth. N. Eng., 1888, 51.

Kakerlac americana, Serville, Hist. Nat. des Orthop., 1839, 68.

Blatta americana, Rathvon, U. S. Ag. Rep., 1862, 375. (In part.)

Packard, Third Rep. U. S. Ent. Comm., 1883, 309, pls. XXV.--XXXV.

From the Oriental roach this species may be readily known by its larger size and its longer tegmina and wings, which, in both sexes, reach beyond the tip of the abdomen. The supra-anal plate is more pointed and the

*For remedies see remarks under *Phyllodromia germanica* or "Croton bug."

notch at the end is narrower and much deeper. The general color is also lighter, being a reddish instead of a mahogany brown, while the pronotum is broadly margined on the sides, and narrowly in front, with yellow which encloses a large bi-lobed brown spot.*

Measurements: Male—Length of body 27 mm.; to tip of wings, 45 mm.; of tegmina, 27.5 mm. Female—Length of body, 30 mm.; greatest width of body, 14 mm.

The American cockroach is, as its specific name indicates, a native of this country; but like *P. orientalis*, it has spread to the four corners of the earth. It is by far the largest species found in the State, but seems to be of rather limited distribution as I know of its occurrence in but two counties, Putnam and Marion. It occurs in numbers in some of the leading hotels of Indianapolis, but usually confines itself to the basement and first floor, and appears to be much more cleanly in its choice of an abiding place than does the closely allied Oriental roach.

II. ISCHNOPTERA, Burmeister (1838.)

Males, with the sub-anal stylets present but minute, and often bent abruptly downward; last abdominal sternite of the female divided; supra-anal plate in both sexes rounded, not notched at the end nor extending as far backwards as the sub-genital. Body narrower and more elongate than in *Periplaneta*, the abdomen not wider than the thorax; in the males, tapering gradually to a rounded point. Legs spined as in *Periplaneta* but the spines not so long and strong as there. Two species occur in Indiana.

3. ISCHNOPTERA PENNSYLVANICA, (DeGeer.) The Pennsylvania Cockroach.

Platamodes pennsylvanica, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 417.

Riley, Stand. Nat. Hist., II., 1884, 172.

Comstock, Intro. Ent., I., 1888, 93.

Blatta pennsylvanica, Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 440.

Ischnoptera pennsylvanica, Packard, Guide, Stud. Ins., 1883, 576.

McNeill, Psyche, VI., 1891, 78.

Ectobia lithophila, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 418.—(juvenile.)

Blatta americana, Rathvon, U. S. Ag. Rep., 1862, 375. (Note and fig. 5 a.)

Tegmina, long and narrow, extending, in both sexes, much beyond the tip of abdomen. Wings as long as tegmina. Disk of pronotum dark brown, margined on sides, and sometimes narrowly in front, with pale

* In this respect it is quite similar to *Ischnoptera pennsylvanica* DeGeer, from which it may be readily distinguished by its much broader body and fissured supra-anal plate.

yellow. Tegmina reddish brown, with the outer basal third rather broadly margined with transparent whitish. Antennæ dusky, reaching back but little beyond the tip of tegmina. Measurements: Male—Length of body, 21 mm.; to tip of tegmina, 27 mm.; of tegmina, 22 mm.; of antennæ, 28 mm.; of pronotum, 5 mm.; width of pronotum, 6 mm. Female—Very nearly the same, the body being a little wider.

This is a native species and is the most common cockroach in the State, being found everywhere beneath the loose bark of logs and old stumps. It is usually seen in the wingless stages, the mature individuals being common only from May to October. The half grown young, described by Scudder, as *Ectobia lithophila*, are of a shining, dark brown color, the dorsal surface of thoracic segments often lighter. As mature specimens are attracted by light, country houses are often badly infested with them; and where food is scarce, the wall paper is sometimes much injured for the sake of the paste beneath. What the hordes of young which dwell under the bark of logs live upon is a question as yet unsettled, but the larvæ of other insects undoubtedly form a portion of their food, as in two instances I have found them feeding upon the dead grubs of a *Tenebrio*? beetle; while living, as well as decaying vegetable matter probably forms the other portion. The mating of the imagoes mostly occurs in late summer and early autumn, the newly hatched young being most abundant from mid September until December. The young in various stages of growth survive the winter in the places mentioned, they being the most common insects noted in the woods at that season. Cold has seemingly but little effect upon them, as they scramble away almost as hurriedly when their protective shelter of bark is removed on a day in mid January with the mercury at zero, as they do in June when it registers a hundred in the shade.

The empty oöthecæ of this species are very common objects beneath the loose bark of logs and especially beneath the long flakes of the shell bark hickory. They are chestnut brown in color, from 7.5 to 10 mm. in length by 4 mm. in breadth, and are much less flattened than those of *Phyllodromia germanica*, or "Croton bug," described below; while the dorsal or entire edge is slightly curved or bent inwards, after the fashion of a small bean. The young, after hatching, evidently escape in the same manner, as do those of the Oriental cockroach, as no break is visible in the empty capsule.

4. *ISCHNOPTERA UNICOLOR*, (Scudder.)

Platamodes unicolor, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 417.

Fernald, Orth. New Eng., 1888, 53.

Ischnoptera unicolor, Scudder, Proc. Bost. Soc. Nat. Hist., XIX., 1877, 92.

McNeill, Psyche, VI., 1891, 78.

A much smaller species than the preceding but, like it, having both wings and wing covers exceeding the abdomen. General color a pale shining reddish brown. Head and posterior margin of pronotum darker as is also the apical third of the abdomen beneath. Antennæ slender, tapering, reaching backwards to the end of the wing covers. Length of body, 12 mm.; to tip of tegmina 19 mm.; of tegmina 16 mm.; of pronotum, 3 mm.

A single male of this species was taken from beneath an electric light in Terre Haute, Indiana, on the evening of June 12, 1892. On May 28, 1893, a number of others were secured in low ground from beneath the bark of a red oak stump. They had evidently just reached maturity and were in company with the imagoes and young of *I. pennsylvanica*. On being exposed to view a number of them flew about 50 feet to a clump of May apple stems, down which they ran and endeavored to hide beneath some dead leaves. Nothing farther of its habits is known by the writer but they are presumably the same as those of *I. pennsylvanica*. It has been noted at no other point in Indiana and heretofore has been recorded only from the New England States, Illinois, and Iowa.

III. *TEMNOPTERYX*, Brunner (1865).

The males of this genus have the sub-anal stylets present, but minute; the last abdominal sternite of the female is broadly rounded and entire; supra-anal plate of both sexes with the apex rounded, entire, equal in length to the sub-genital. Pronotum with its lateral edges roundly deflexed as in *Periplaneta*, rather than flaring outwards as in *Ischnoptera*; much broader in the female than in the male. Body of male rather slender; that of female stouter with the abdomen broader than the thorax.

5. *TEMNOPTERYX DEROPELTIFORMIS*, Brunner.

Temnopteryx deropeltiformis, Brunner, Nouv. Syst. des Blattaires, 1865, 87.

Tegmina of females rudimentary covering only about one-third of abdomen; those of the males fully developed, surpassing the abdomen by 5 mm. Color a uniform dark mahogany brown except the tibiae and tarsi of all the legs which are a light reddish brown, the contrast between the two colors in living specimens being very striking.

Measurements: Male—Length of body, 14 mm.; of tegmina, 15.5 mm.; of pronotum, 3.5 mm.; width of pronotum, 4.5 mm. Female—Length of body, 13 mm.; of tegmina, 4 mm.; of pronotum, 4.5 mm.; width of pronotum, 6 mm.

In Indiana this handsome cockroach has been noted only in Vigo county, and there in but one locality, the border of a marsh in a low, sandy woods three miles east of Terre Haute.

A single pair were taken on May 28th, and on June 18th probably a dozen specimens were secured. They were hiding beneath small logs and sticks, and the males when deprived of their shelter flew actively away while the females could but crawl, and that rather sluggishly for a Blattid, towards a new hiding place.

Brunner (*loc. cit.*) recorded it from "Amerique du Nord," and I can find no other note of its occurrence in the United States.

IV. ECTOBIA, Westwood (1839).

Sub-anal stylets of males wanting; last abdominal sternite of females entire. Supra-anal plates rounded, entire, somewhat carinated above. Abdomen much broader than front portion of body, its greatest breadth contained less than twice in its total length. Tegmina, in both sexes, not reaching tip of abdomen.

6. ECTOBIA FLAVO-CINCTA, Scudder. The Short-winged Cockroach.

Ectobia flavo-cincta, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 418.

Comstock, Intr. to Ent., I., 1888, 93.

Blatta? flavo-cincta, Fernald, Orth. N. Eng., 1888, 51.

This is a short, broad-bodied, native species, in which the tegmina cover only about two-thirds of the abdomen, while the wings are much shorter. The disk of pronotum and dorsal surface of abdomen are dark brown, the tegmina reddish brown. A rather broad yellowish stripe extends from the head along the deflexed lateral border of pronotum and the basal third of tegmina. The sides of the lower half of the face are white, and all the limbs are pale yellow. Antennæ dark brown, a little longer than the body.

Measurements: Length of body, 16 mm.; of tegmina, 9 mm.; of wings, 6.5 mm.; of antennæ, 18 mm.; of pronotum, 5 mm.; width of pronotum, 6.5 mm.; width of abdomen, 9.5 mm.

Mature individuals of this species are not uncommon beneath bark and logs from June to October. Specimens of such are in my collection from Marshall, Putnam, and Vigo counties. I have not, as yet, been able

to distinguish the young from those of *Ischnoptera pennsylvanica*, found in the same localities. A single female with oötheca protruding was taken on September 3, 1892. The oötheca is dark brown and smaller than that of any other species known to me, measuring only 5x4 mm.

Flavo-cincta is a species of northern range, having hitherto been recorded only from New England and the Lake Superior region.

V. PHYLLODROMIA, Serville (1839).

Sub-anal stylets and last abdominal sternites, as in *Ectobia*. Supra-anal plate truncate in the males, suddenly pointed and slightly notched in the females. Body narrow, the greatest breadth contained from two and one-half to three times in the total length. The abdomen not broader than the thorax in either sex, the sides almost parallel in the females; in the male tapering sensibly from the base. The tegmina as long as, or longer than, the abdomen.

7. PHYLLODROMIA GERMANICA, (L.) The Croton Bug. The Water Bug. The German Cockroach.

Blatta germanica, Burmeister. Handbuch der Ent., II., 1838, 497.

Comstock, Int. Ent., I., 1888, 93, fig. 87.

Fernald, Orth. N. Eng., 1888, 50, fig. 20.

Ectobia germanica, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 418.

Glover, U. S. Agl. Rep., 1874, 132, fig. 3.

Riley, Stand. Nat. Hist., II., 171, fig. 247.

Id. Insect Life, I., 1888, 68, 191.

Blatta (Phyllodromia) germanica, Serville, Hist. Nat. des Ortho., 1839, 107.

Phyllodromia germanica, Packard, Guide Stud. Ins., 1883, 576, fig. 569.

Riley, Insect Life, II., 1890, 266, fig. 57 (All stages.)

Ischnoptera bivittata, Thomas, Proc. Davenport Acad. Nat. Sci., I., 1876, 250, pl. XXXVI, figs. 1, 2.

This is the smallest of the seven species of Blattidæ which are known to occur in the State. The general color is a light brownish yellow, the females often darker; all the limbs much lighter than the body; the pronotum with two dark brown, longitudinal bands enclosing a yellowish stripe. The tegmina and wings of the male extend to the end of abdomen, those of the female are a little longer. Antennæ dark brown, exceeding slightly the tips of the closed tegmina. The body of the male is longer and narrower than that of the female.

Measurements: Male—Length of body, 13 mm.; of tegmina, 10 mm.;

width of body, 4 mm. Female—Length of body, 10 mm.; of tegmina, 11 mm.; of antennæ, 13 mm.

The oötheca of the Croton bug is very light brown, a little over twice as long as broad, 7.5x3.5 mm., with the sides somewhat flattened and the edges parallel. Within it the eggs, thirty-six in number, are arranged in the usual two rows. It is carried about by the mother roach for several days with from half to three-fourths of its length protruding from the abdomen, and when dropped in a favorable place the young, evidently very soon, emerge from it; for in a bottle in which a female with protruding oötheca was placed at eleven o'clock P. M. the young were found to have emerged on the following morning at eight. They were then wholly white, except the lateral edges of the abdomen, where a blackish tinge was evident. By five o'clock in the afternoon of the same day, having meanwhile eaten their fill of moistened wheaten bread, they had become too large for their skins, and had moulted for the first time. They then measured 3 mm. in length, and the head, pronotum, abdomen, and apical half of antennæ were black, while the other two thoracic rings and the basal half of antennæ were a grayish white. The half-grown young are very dark brown, with the first four or five segments bordered with yellow, and with traces of a lighter median stripe.

The "Croton bug," so called because it made its appearance in New York City in numbers about the time the Croton Aqueduct was completed, is a native of Central Europe, but like the Oriental roach, has become cosmopolitan.

It seldom if ever occurs in numbers in the country, but is one of the worst insect pests with which the inhabitants of the larger cities of the United States have to deal. It is the most fecund of all the roaches, and the seasons of mating and hatching of the young are, perhaps, more irregular than in any other species. Adult forms are evidently to be found at all seasons of the year, as I have taken them in December, April and October. It is not so much a lover of filthy surroundings as is the Oriental roach, and hence frequents more often than that species the dwellings of the better class of people. It delights in warm, moist places, and is especially abundant and destructive in buildings which are heated by steam.

As an evidence of its abundance under favorable conditions, I will mention that a single person captured for me over thirty adult specimens and fully half that number of young, in less than ten minutes in the kitchen

of the leading hotel of the city of Terre Haute. Where it once obtains a foothold and the surroundings of temperature and food supply are favorable it is almost impossible to eradicate, as its small flattened form enables it to hide and breed in cracks and crevices which none of the other roaches can enter.

Like many other omnivorous animals, Croton bugs find in wheaten flour a food substance which is rich in nutrition and easily digested, and so they prefer wheat breads and starchy materials to all other foods. On account of this liking they often do much harm to cloth-bound books by gnawing their covers in search of the paste beneath. They also seem to have a peculiar liking for paints of various kinds, and in the office of the U. S. Coast and Geodetic Survey, at Washington, have done much damage by eating off the blue and red paints from the drawings of important maps.* Townend Glover, in the U. S. Ag. Rep. for 1874, states that in his office "They made a raid on a box of watercolors where they devoured the cakes of paint, vermilion, cobalt and umber alike; and the only vestiges left were the excrements in the form of small pellets of various colors in the bottom of the box."



In giving a remedy for this, and other species of Blattidæ which frequent houses, I cannot do better than quote from Dr. Riley's excellent article in "Insect Life." He says: "Without condemning other useful measures or remedies like borax, I would repeat that in the free and persistent use of California Buhach, or some other fresh and reliable brand of Pyrethrum or Persian Insect Powder, we have the most satisfactory means of dealing with these roaches.

"Just before nightfall go into the infested rooms and puff into all crevices, under base-boards, into the drawers and cracks of old furniture—in fact wherever there is a crack—and in the morning the floor will be covered with dead and dying or demoralized and paralyzed roaches, which may easily be swept up or otherwise collected and burned.

"With *cleanliness*, and *persistence* in these methods, the pest may be substantially driven out of a house, and should never be allowed to get full possession by immigrants from without."

For no other insects have so many quack remedies been urged and are

* Riley, "Insect Life."

so many newspaper remedies published. Many of them have their good points, but the majority are worthless. In fact, rather than put faith in half of those which have been published, it were better to rely on the recipe which T. A. Janvier gives (in his charming article on "Mexican Superstitions and Folk-lore," published in a recent number of *Scribner's Magazine*) as current among the Mexicans:

"To Get Rid of Cockroaches.—Catch three and put them in a bottle, and so carry them to where two roads cross. Here hold the bottle upside down, and as they fall out repeat aloud three *credos*. Then all the cockroaches in the house from which those three came will go away."

A NOTE ON *LOXIA CURVIROSTRA*. By W. S. BLATCHLEY.

ON A SIMPLE AIR THERMOMETER FOR USE IN DETERMINING HIGH TEMPERATURES.

By W. A. NOYES.

[ABSTRACT.]

The thermometer consists of a bulb of hard glass having a capacity of about 20 cc. and connected with a gas measuring tube by means of a long capillary tube. This tube is protected by means of a double walled iron tube cooled by a stream of running water. The capacity of the bulb having been determined, the amount of air expelled from it when it is introduced into the furnace furnishes the data necessary for calculating, approximately, the temperature. The apparatus was used successfully at 650° C. but for higher temperatures a porcelain bulb would be required.

THE ELECTRICAL OXIDATION OF GLYCERIN. By W. E. STONE AND H. N. MCCOY.

[ABSTRACT.]

The oxidation products of glycerine vary according to the means employed. We have made use of the electric current acting upon dilute solutions of glycerine in the hopes of obtaining glyceric aldehyde. The conditions of dilution, strength of current, temperature and conducting mediums have been varied.

The oxidation is less destructive in neutral or alkaline solutions.

A current of .2 to .5 ampere causes a rise in temperature and the appearance of a yellow color if the solution be alkaline.

Acids and sometimes acrolein are formed.

The oxidized solutions reduce Fehling's solution strongly in the cold and give the fuchsin-sulfurous acid reaction for aldehydes.

To a solution which gave strong reactions for glyceric aldehyde was added enough caustic soda to make a 2 per cent. solution in order to induce polymerisation. After standing some days, a phenylhydrazin compound was obtained, which melted at 200°. This indicated the production of glyceric aldehyde and its polymerisation to glucose.

The product of a second oxidation was polymerised and underwent alcoholic fermentation with yeast.

The electric current, therefore, produces some glyceric aldehyde from glycerine, although the amount is small.

ON SULPHON-PHTHALEINS. By WALTER JONES.

MODIFICATION OF GRANDEAU'S METHOD OF DETERMINATION OF HUMUS IN SOILS,

By H. A. HUSTON AND W. F. MCBRIDE.

The paper discusses the numerous methods proposed and used for determining the total carbon in the soil and for determining the organic matter and shows that none of these methods are entitled to consideration excepting the process of Grandeau. This method, which consists essentially of removing the bases combined with the humic acid by means of hydrochloric acid, subsequent washing with water and extracting on a filter with ammonia water, is compared with a modification of the method in which the preliminary washing with acid and water is the same but, instead of leaching the soil upon the filter with ammonia water, the soil is transferred to a 500 cc. cylinder, treated with 500 cc. of 4% ammonia, allowed to remain in contact with the ammonia for thirty-six hours, with frequent shaking. During the earlier part of the digestion the cylinder is left upon its side, thus exposing a large amount of surface to the solvent; during the last twelve hours of the digestion the cylinder is placed upright,

thus allowing the soil to settle before an aliquot part is removed for the determination of the humus.

The aliquot part is evaporated to dryness, dried at 100° C., weighed, ignited, weighed again and the loss reckoned as humus. The following points were under discussion:

- 1st. Comparison of Grandeau's method with this modified method.
- 2d. Influence of varying the strength of the ammonia used.
- 3d. Influence of varying the time of digestion.
- 4th. Is it possible to complete the extraction by Grandeau's method in a reasonable time.
- 5th. Comparison of differences in duplicates by each method.
- 6th. Are the amounts of phosphoric acid, potash, etc., found in the ash necessarily associated with the humus, as claimed, or are they to be ascribed to the solvent action of the ammonia and to changes due to the absorptive property of the soils.

Numerous determinations are given upon seven different soils, showing that the modified method gives much higher results than the ordinary process of Grandeau.

Second, In the Grandeau method marked irregularities follow the changes in strength of the ammonia solution. These differences in results bear no relation to the strength of the solution used; they seem to be errors due to the difficulty of securing a complete washing of the soil by the ammonia solution. In the modified method the changes in the strength of the ammonia solution make practically no difference in the amount of the humus extracted, excepting in the case of the peat soil, where 2% ammonia failed to extract all the humus. The results show no considerable increase where the strength is increased above 4%. The ammonia solutions contained 2, 4, 7.3 and 8% of ammonia.

Third, The increase of time has not been fully investigated but the results so far obtained indicate that the time exerts less influence in the modified than in the Grandeau method.

Fourth, With peat, when the Grandeau method is used, considerable material is passing into solution at the end of ten days; with ordinary soils this is not the case, but in the case of the black soil (not peat) the extraction was not complete in a week. On the peat soil the modified method extracted from 10 to 50% more than the Grandeau and on ordinary soil from two to three times as much humus.

Fifth, In comparing a large number of duplicates the modified method

was found to give much more concordant results upon soils high in humus, and upon those low in humus there was a slight improvement over the Grandeau method.

Sixth, The authors see no reason for assuming that the phosphoric acid extracted by the ammonia is in any way associated with the humus, for Mr. Huston has already shown that the phosphoric acid is readily dissolved by ammonia from phosphate of alumina and iron. It is generally considered that there are bases with which the available phosphoric acid in the soil is combined. In the same way we may account for the presence of potash and lime in solution by the ordinary laws which govern the absorption of bases by zeolitic minerals in the soil.

While humates also take part in soil absorption, it is not necessary or even altogether reasonable to consider all the bases removed by ammonia were associated with the humus. In fact, the theory of the process is that the bases associated with the humus had already been removed by means of the hydrochloric acid used in the preliminary washing of the soil.

The paper is in the nature of a preliminary report and the work is still in progress. A complete report of the work will be published later.

THE EXTRACTION OF XYLAN FROM STRAW IN THE MANUFACTURE OF PAPER.

By W. E. STONE AND W. H. TEST.

[ABSTRACT.]

The extraction of substances from straw which on inversion, yield a pentose sugar, has been established. In the process of making straw paper the straw is boiled with a strong solution of quick lime. This liquor, when acidulated and treated with an excess of alcohol throws down a precipitate of pentosans. It seemed, therefore, a good material for the preparation of xylose.

The liquor is yellowish brown in color and alkaline. Specific gravity, 1.215; alkaline equivalent, 2 to 2.5 per cent. calcium oxide. Total residue on evaporation, 3.95 per cent., of which 30.77 per cent. was mineral and 69.23 per cent. organic in nature. Thirty-two liters of the liquor yielded on precipitation with alcohol, 300 grams of xylan. This, on distillation with hydrochloric acid, yielded 45.5 to 47.1 per cent. furfural. This could not be inverted by methods similar to those practiced by Wohl on inuline. The ordinary method of boiling with 2 per cent.

sulfuric acid was resorted to. Thirty-five grams of crystallized sugar were obtained, which were identified as xylose.

The multirotation of xylose, as observed by Tollens, was confirmed. The initial rotation, five minutes after solution, was 71.65° , which became constant at 18.40° after ten hours.

ON THE DETERMINATION OF CHLORINE IN NATURAL WATERS. By W. A. NOYES.

[ABSTRACT.]

American waters, apparently, contain much smaller amounts of chlorine than most natural waters in England. The methods of direct titration with silver nitrate and potassium chromate as advised by Wauklyn and Frankland give too high results, and sometimes two or three times as much chlorine as is actually present, in the case of waters low in chlorine. When 250 cc. of the water were concentrated to about 25 cc. and filtered, the titration with $\frac{1}{100}$ normal silver nitrate, using potassium chromate as an indicator, gave results agreeing with the gravimetric determination within $\frac{1}{10}$ part per million in the case of a water containing but four parts per million of chlorine.

THIOFURFUROL AND ITS CONDENSATION PRODUCTS. By W. E. STONE AND CLINTON DICKSON.

[ABSTRACT.]

Thiofurfurol is made by the action of hydrogen sulphide on an alcoholic solution of furfuramid. It is characterized by its disagreeable odor. It is a white powder, melting at 117° and containing about 29 per cent. of sulphur, corresponding to the formula C_5H_4OS . On heating strongly vapors are given off which, on condensation, leave beautiful fibrous crystals, which are not easily acted upon, probably a condensation product. If the thiofurfurol be heated with an excess of fine copper at a temperature below the boiling point of water decomposition takes place. On extracting the mass with ether and evaporating, there remains a tarry mass which yields compact crystals which melt at 149° , contain no sulphur and are probably also a condensation product. The subject will be investigated further.

DETERMINATION OF VALENCES. By P. S. BAKER. Published in DePauw Bulletin.

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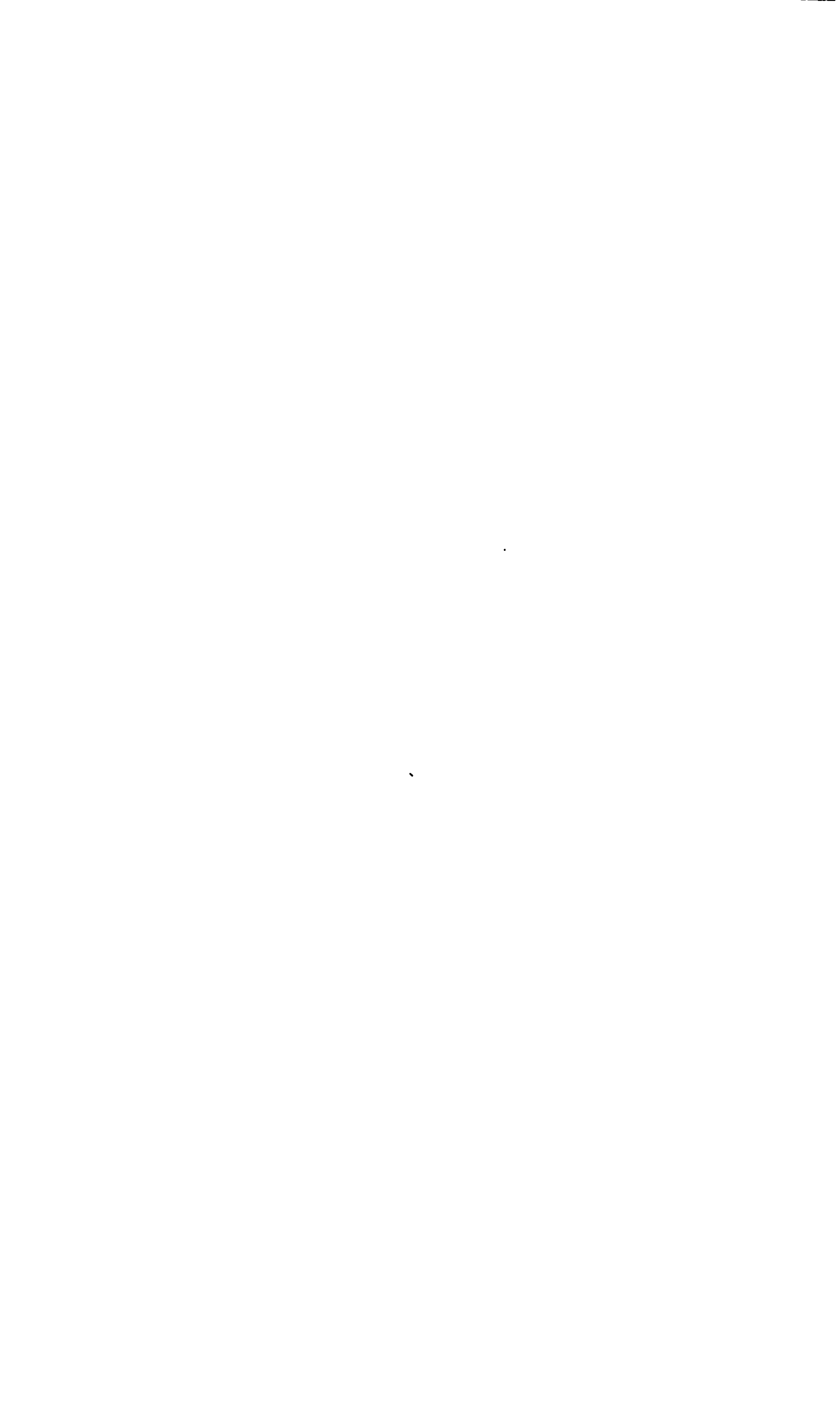
Indiana Academy of Science.

1893.

BROOKVILLE, IND

PUBLISHED BY THE ACADEMY

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1893.

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CONSTITUTION.

ARTICLE I.

SECTION 1. This Association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter, an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the state. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men and who have been members of the Academy at least one year may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of Members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee be elected as fellows. At the meeting at which this is adopted the members of the Executive Committee for 1894 and fifteen others shall be elected fellows and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, vice president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices, and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting, appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis, within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the executive committee. Other meetings may be called at the discretion of the executive committee.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.

3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

6. Ten members shall constitute a quorum for the transaction of business.

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REPORT OF THE BOTANICAL DIVISION OF THE INDIANA STATE BIOLOGICAL SURVEY.

LUCIEN M. UNDERWOOD, DIRECTOR.

The Indiana Academy of Science at its spring meeting originated the State Biological Survey by the appointment of three directors who were instructed to organize the survey and prepare for the winter meeting a Bibliography that would show the present status of the knowledge of the state flora and fauna, recording in accessible form what had been already written concerning them. It was further thought desirable to outline certain features of new work that could be reasonably attempted during the season of 1893. In order to make known the purposes of the survey the following general statement was published and somewhat widely distributed through the state in July last:

BIOLOGICAL SURVEY OF INDIANA.

CIRCULAR No. 1.

At the last meeting of the Indiana Academy of Science, at Terre Haute, a Biological Survey was established for the State of Indiana, and the undersigned were appointed Directors to organize the survey and outline the preliminary work ordered by the Academy.

It is the purpose of the survey:—(1) To ascertain what has already been accomplished in the direction of making known the character and extent of the life of the state, and to this end to prepare a complete bibliography of materials bearing on the botany, zoology and palæontology of Indiana, to be published by the Academy. (2) To associate the various workers throughout the state, and so correlate their labors that all will work together towards a definite end, and ultimately accomplish the main purpose of the survey, namely,—the making known of the entire fauna and flora of Indiana, its extent, its distribution, its biological relations, and its economic importance. (3) To stimulate the teachers of biology throughout the state to encourage in their pupils the accumulation of material, which shall make known the local extent and distribution of life-forms, and thus contribute facts that will be useful in the survey and at the same time develop acute observers for continuing the study of the natural resources of the state. It is thus intended that the colleges and secondary schools will form with the survey a mutually helpful relation. (4) Ultimately to secure for the Academy a collection that will illustrate the biology of the

state. Until such collection can be otherwise provided for, the Academy will designate certain public or private collections where accumulated material may be deposited temporarily. Material sent to the directors will be thus held for the future disposition of the Academy.

It is earnestly requested that all persons interested in any department of biological work will place themselves in relation with the directors of the survey at once, in order that their work may be made to contribute the most effectively to the public good, and in order that the directors may know on whom they may depend for gaining information from various portions of the state. All contributions from persons interested will be properly credited in the reports of the survey. Correspondence is solicited with the director of the particular branch in which any one is interested, and such directions in regard to collecting and sending material will be given on application. By the assistance of the Smithsonian Institution, the directors are able to send printed directions for collecting to such as apply for them. (In ordering these it will be necessary to specify in what particular branch information is desired.)

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1 July 1893.

Directors of the Biological Survey of Indiana.

In addition to the above the following was sent out by the Botanical Division:

SPECIAL ANNOUNCEMENT OF THE DIVISION OF BOTANY.

It is the purpose of this Division during the present year to make such additions and corrections to the published "Catalogue of the Plants of Indiana" as are possible, and to secure definite information regarding the distribution of such rare forms as are there published. Specimens illustrating the distribution or occurrence of any plant within the limits of the state must be deposited with the survey before any notice of their belonging to the state flora can be published. This will insure the ability to verify in future any fact published by the survey. In sending such material it is desirable that notes on the station, habitat, range and abundance of the plant be noted, together with any other information that will be of value.

In addition to the flowering plants and ferns covered in the above, it is the intention of the Division to commence the study of the distribution of the lower cryptogams, concerning which almost nothing has been published from Indiana. While collections will be made of all forms, special attention will be given at present to the study of (1) Mosses, (2) Hepaticæ, and (3) Parasitic Fungi. Specimens are earnestly desired of all species,

even those that are most common, from all portions of the state. It is desirable to state with each species the data indicated above, with particular reference to the habitat. In the case of parasitic fungi, it is necessary to indicate the host, and to include sufficient quantity of the host plant, that doubtful determinations may be verified. The director has been promised the assistance of specialists in the study of material accumulated.

LUCIEN M. UNDERWOOD, Director,
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The Bibliography called for by the Academy has been prepared and is presented with this report as Appendix A. It has involved the actual page to page examination of large files of journals and while doubtless incomplete will when published serve as a basis for periodical additions.

As far as possible, personal collections have been made; but with the demands of a full laboratory upon the director there has been little time for either extensive field work or opportunity to fully determine the material collected. The season also was especially unfavorable from the long drought that lasted from June to September. In addition to the spring excursion to Vigo county I made a second trip to the same region in late October. One trip was made to Lake Maxinkuckee and the tamarack swamps in the vicinity of Kewanee, Fulton county. Another was made to Brown county in May. Two trips were made to Eel River Falls in Owen county, one in May and the other in October. Some collecting was done in the vicinity of Crawfordsville but the greater amount has been accomplished in the vicinity of Greencastle in Putnam county. While all groups of cryptogams have been collected, special attention has been given to those mentioned in the circular. Of the parasitic fungi the fullest collections were made in the Erysiphæe. Of these we have doubtless an almost complete collection and a few comparisons with the flora of adjoining states may be to the point. In Illinois, the report by Burrill and Earle* includes 27 species. Of these all but one have been found in Indiana (*Spharotheca pruinosa* C. & P., on *Rhus glabra*). In Ohio the report of Selby† includes 24 species. Of these all have been found in Indiana except the unique *Uncinula Columbiana* on *Scutellaria lateriflora*. The entire number found in Indiana is 33 which exceeds the Illinois list by 6 species and the Ohio list by 9 species. Of other groups, the Uredineæ have been most abundantly collected. So far, the Ustilagineæ and Peronosporæ have not been found abundant.

* Burrill and Earle, Parasitic Fungi of Illinois. Part II. Bull. Illinois State Lab. Nat. Hist. 2: 387-432, 1887.

† Selby. The Ohio Erysiphæe. Bull. Ohio Agric. Exp. Sta. 1: 213-221. Ap. 1893.

In addition to the personal collections above noted, there has been a reasonable amount of willingness expressed on the part of botanists elsewhere in the state to co-operate in making known the cryptogamic flora of their respective localities. The most serviceable aid in this direction has been rendered by Professor M. B. Thomas, and his assistant, Mr. E. W. Olive. During the past autumn they have collected and identified 120 species of parasitic fungi from the vicinity of Crawfordsville. It is likely that during the present winter season and especially during the coming summer we may hope for much local work of this character. So long as the survey is conducted on a purely voluntary basis this local work is a necessity and it is to be hoped that by this means much will be accomplished in the direction of determining the extent and range of our flora. One great lack among local workers is the lack of literature. So far as the colleges are concerned only three, perhaps, offer more than minimum opportunities in this direction. So far as I am aware there is only one copy of Saccardo's *Sylloge Fungorum* in any library in the state, and other literature is almost equally lacking, even in libraries where more is expected. There has also been a seeming fear on the part of some that work in systematic botany would prove an injury if attempted in connection with a course of botanical study, and that anything short of work in cytology was undignified in a botanical laboratory. It is certain that the swing of the pendulum has reached its outward limit in this direction and that systematic botany, particularly that of the cryptogams is likely to demand more serious and general work than it has hitherto been accorded in America. So far as the laboratory with which the director is concerned, we will say that the fullest opportunities will be given to any local workers who may wish to use its library and collections.

In order to make representative species more accessible to local workers, the survey has planned the issue of a series of exsiccatae of Indiana cryptogams for distribution among public and private collections, where they may become serviceable. The conditions of this gratuitous distribution will be given privately, though it may be here stated that sets will be placed in at least four of the colleges of the state that maintain a permanent herbarium. Of course the labor involved in preparing these sets

Ample works are here accessible for ordinary systematic reference in the fungi, hepaticae and musci. The literature of the algae and lichens though considerable is not so extensive. The same is even more true of the collections, as may be seen in the note below.

makes the number to be issued very limited. The first two fascicles of Parasitic Fungi (100 species) are nearly ready for distribution. If the matter receives sufficient encouragement, succeeding fascicles will illustrate the Musci, Hepaticæ, Hymenomycetes, Pyrenomycetes and Lichenes, respectively.

Turning now to the higher plants, we find them, of course, better known but their local distribution is a matter of great interest and one on which little definite information is at hand. In the only published state flora* 1,475 species are recorded. Many additions have been made to this list by more or less reliable collectors, and the thorough examination of the unexplored portions of the state will doubtless reveal many others. The accompanying map will show how much of Indiana is yet a *terra incognita* botanically.† As an illustration of how common plants may be passed by, I will cite the case of the common cockle-bur. In the state flora *Xanthium strumarium* and *X. spinosum* are recorded. Growing with the former in Putnam county though less common is the allied *X. Canadense* and we have also found it in the vicinity of Crawfordsville. The two, quite similar in appearance, though common weeds, have evidently been confused together though both are doubtless more or less widely distributed, especially in the northern portions of the state.

The revision of the higher flora we have placed in the hands of Professor Stanley Coulter to whom all material will hereafter be referred. Professor Coulter has at our request prepared a paper on the present status of the Phanerogamic Flora of the state. It is desired in this connection (1) To ascertain what plants have been added to the flora since the catalogue was published, by securing either from those who originally reported them or otherwise a set or sets of these plants that may be placed in some herbaria for future reference. A list of these will be published later but it is the intention of the survey to admit no empty names to the list; until the plants themselves accompany the name as a voucher, they will be rigorously excluded. (2) To verify the plants of the catalogue itself either by material now in some existing collection or by the collection of new material in the original or other localities. It is thus intended to have some-

*Catalogue of the Phanogamous and Vascular Cryptogamous Plants of Indiana. By editors of the Botanical Gazette and Prof. Charles R. Barnes, Crawfordsville, Indiana, 1881. Supplement I. April, 1882.

†The map presented with this report is not reproduced here. It showed that less than one-third of the counties had been entered by a field botanist, and that not over a dozen could be said to have been botanically explored.

where an accessible set of the plants of the entire state which may serve as the basis of a complete catalogue.

In regard to the assistance that local and amateur botanists can render the survey we will say that their work can be made of inestimable value if properly directed. The publication of county lists with nothing back of them except the opinions of persons whose general acquaintance with the flora of the country is slight, is not to be encouraged. Back of every note and every local list there ought to be a well kept collection, and in the case of rare plants there should be duplicates placed in some one of the larger public collections so that the identity of the plant in question can be placed beyond the danger of being lost as soon as the novelty of the first collection wears off. The colleges at least where botany is made a subject of some importance ought to have a collection of state plants for constant reference. In some of the larger high schools also the collection of the local flora can be made a useful adjunct of the year's study of botany and the town high school can thus serve as a local centre of botanical interest that will keep alive the local development of the subject among many who would otherwise drift away from botany into something else. Nor should this interest be confined to "manual" plants. Mosses, lichens, fungi and algae should also form a rational part of the field study even in the high school period.

Finally we invite a thorough co-operation of all the workers of the state to assist in placing the definite record of the Indiana flora in safe keeping, and develop as widely as possible the knowledge of the extent and distribution of the plants of the state.

It is deemed advisable to present as complete a list as possible of the Indiana cryptogams that have been collected already in order that it may serve as the starting point for further work. In this list nothing is admitted unless accessible specimens exist in some collection that is likely to become permanent.* We include therefore the following material:

* Most of the specimens herein named are deposited in the Underwood Herbarium as probably the largest cryptogamic collection in the state. This collection so far as the plants below the Pteridophytes are concerned contains the various groups as follows:

Musci—About 900 species represented by about 3,000 specimens.

Hepaticae—About 1,300 species represented by about 7,000 specimens.

Fungi—About 3,500 species represented by about 9,000 specimens.

Lichenes—About 300 species represented by about 800 specimens.

Algae—About 200 species represented by about 300 specimens.

With the Pteridophytes of the collection the herbarium contains nearly 8,000 species represented by some 25,000 specimens. Except the ferns, this collection has been accumulated mainly since 1887 and contains numerous rare exsiccates.

1. Material collected mostly about Lafayette by Dr. J. C. Arthur and H. L. Bolley. This is preserved in their own private collections and in most cases duplicates have been placed at my disposal.

2. Some mosses collected by W. S. Blatchley in Monroe and Vigo counties.

3. Material collected by E. M. Fisher mostly in Montgomery and Johnson counties and deposited in the herbarium of the Department of Agriculture (Division of Vegetable Pathology).

4. Material collected by M. A. Brannon illustrating a paper on "Some Mildews of Indiana," read before the Academy 1889. Duplicates of most of this material have also been placed at my disposal.

5. Material collected in the vicinity of Crawfordsville in 1893 mainly by E. W. Olive. Duplicates of this material have been contributed to the survey.

6. Material collected by the writer in various counties of the state, 1891-1893, including that collected since the organization of the survey.

7. Occasional miscellaneous species collected by various individuals and in our possession.

The above represents all the cryptogamic material that is known to belong to the state flora that is accessible at present. Some few additional lists have been published but as they are not represented by accessible specimens they are not considered here.

Thanks are due to the following who have identified certain materials in the line of their specialties: Prof. D. C. Eaton, Prof. R. Thaxter, Prof. G. F. Atkinson, Prof. C. E. Cummings, Prof. C. R. Barnes, Charles H. Peck, J. B. Ellis, E. W. D. Holway. Much assistance has been rendered by various students in my laboratory in the preliminary determination of material.

Thanks are also due to the managers of the Vandalia road for various favors that have made more extensive collections possible.

LUCIEN M. UNDERWOOD.

Greencastle, Indiana, December 5, 1893.

APPENDIX A.

BIBLIOGRAPHY OF INDIANA BOTANY.

Comparatively little material is at hand to record the early botanical work done within the limits of the present state of Indiana, though it is doubtless a fact that could the history be correctly told it would present many features of interest. The first recorded item of the history dates back just a century for we know that Michaux came to Louisville, Kentucky, in July 1793, and collected plants in that vicinity, and that later (1795), he ascended the Wabash as far as Vincennes. Thomas Nuttall botanized along the Ohio river to its mouth in 1818. A little later the erratic Rafinesque, who was professor of natural science in the University of Lexington, Ky., 1819-1826, collected in states to the north and south of his home and was an occasional visitor in our state. The establishment of the communistic society at New Harmony made that place a rendezvous for all the visiting naturalists and when the full history of that enterprise is written, there will be much of interest connected with these visits. Among them Maximilian, Prince of Neuwied, spent a winter there (1832-3) and published a list of the trees of the vicinity in 1839. During this period also, Riddell and Short were botanizing along the southern borders of the state, and Lapham of Wisconsin, occasionally collected grasses and other plants in the northern parts. In 1835 Dr. Clapp of New Albany made considerable collections in that vicinity, a part of which is still preserved in the herbarium of Wabash College. Alphonso Wood once resided at Terre Haute and made considerable collections in the state.

The commencement of the series of county floras was made by Professor A. H. Young for Jefferson county in 1871, soon followed by one for the lower Wabash Valley by Dr. Schneck of Mt. Carmel, Ill. Two additional lists of Jefferson county plants have been made, the second by John M. Coulter and the third by Charles R. Barnes. Other similar lists have followed: for Noble county by Van Gorder, Steuben by Bradner, East Central Indiana by Phinney, Franklin by Meynke, Dearborn by Collins, and Clark by Baird and Taylor. In addition to these several have been prepared, but not published: Putnam by MacDougal, Monroe and Vigo by Blatchley, Henry by Mrs. Mikels, and Knox by Spillman. The unfortunate feature about most of these publications is the fact that nothing exists but the original list. In many cases not a single specimen stands behind the list, so

that verification of doubtful plants will be impossible until additional material is collected.

Probably the greatest impetus to the study of Botany in Indiana was given by the founding of the Botanical Bulletin in November 1875, soon changed to the Botanical Gazette. Its original form was quite unlike its present magnitude—a four page sheet without cover in place of its present 40 page issue. Its contents also were as unlike the present as can be well imagined and the file of this journal may well be taken to represent the splendid progress made in the science of Botany in America during the past two decades. The first numbers were largely filled with local notes and the entire journal during the first few years of its existence shows its strictly provincial character. In 1881 this journal published a catalogue of the state flora including nearly 1,500 plants stopping with the ferns. In the preparation of this flora, much assistance was received from Rev. E. J. Hill regarding the flora of the northern counties of the state and he has since contributed many notes regarding the rarer plants of that region. This portion of the state has further received some attention from Messrs. Higley and Raddin in their flora of Chicago and vicinity.

The story of the study of the cryptogamic flora of the state is soon told. *Uromyces lespedezae* seems to have been the first of the lower cryptogams to be reported in 1876 by John M. Coulter. Sixty-nine species of mosses were reported from Southern Indiana by A. H. Young in 1876, and a number of Mosses and Lichens were reported from Wayne county by Mrs. Haines. Both these collections are in existence but they are not accessible for reference at the present time. H. L. Bolley and Dr. J. C. Arthur have collected some material from the vicinity of Lafayette; among that collected by Mr. Bolley were several interesting Uredineæ on *Carex* and other Cyperads. Those collected by Dr. Arthur were mostly species of economic interest. In 1890 E. M. Fisher, under appointment of the Department of Agriculture at Washington, collected a considerable number of parasitic fungi mostly in Montgomery and Johnson counties. J. N. Rose and M. A. Brannon have each had a brief struggle with the powdery mildews and W. H. Evans at one time made some collection of the lichens, but the material does not seem to be in existence at present. Dr. Julius Röhl made extensive collections of mosses in America and a considerable number of species from Hobart, Indiana are included in his list. This sums up in brief, the history of botanical collection and local workers in Botany to the time of the organization of the Biological Survey.

The following papers have been published to date which bear more or less directly on the state flora. Many additional data concerning Indiana plants are given in the various manuals of botany which have not been included in this enumeration:

Arthur, Joseph Charles. Spotting of Peaches and Cucumbers. Bull. Ag. Exp. Sta., Indiana, No. 19. (Jan. 1889.)

Account of *Cladosporium carpophilum* and *C. cucumerinum*.

———Smut of Wheat and Oats. Bull. Ag. Exp. Sta., No. 28. (Sept. 1889.)

Account of *Tilletia foetens* and *Ustilago avenae*.

———Treatment of Smut in Wheat. Bull. Ag. Exp. Sta., No. 32. (July, 1890.)

Methods of controlling stinking smut of wheat (*Tilletia foetens*).

———The Loose Smut of Oats. Bull. Ag. Exp. Sta., No. 35. (Mar. 1891.)

Account of treatment of *Ustilago avenae*.

———Treatment of Powdery Mildew and Black Rot. Bull. Ag. Exp. Sta., No. 38. (March, 1892.)

Brief account of treatment of *Uncinula ampelopsidis* and *Leetadina Bidwellii*.

Arthur, J. C., and Golden, Katherine. Diseases of the Sugar Beet Root. Bull. Ag. Exp. Sta., No. 39. (April, 1892.)

Account of "Beet Scab," attributing it to a bacterial disease.

Bailey, Liberty Hyde. Limits of Michigan Plants. Bot. Gazette, 7: 105-108. (Sept. 1882.)

Notes on some Indiana plants.

Baird, John F., and Taylor, John L. The Flora of Clark county, Ind. Manual of the Pub. Schools of Clark county, Ind., for 1878-9, 45-65.

Barnes, Charles Reid. Notes [on various plants]. Bot. Gazette, 2: 120-121. (July, 1877.)

———Addenda [to flora of Jefferson county]. Bot. Gazette, 3: 13. (February, 1878.)

Adds three species to previous lists.

———Catalogue of Phanogamous and Vascular Cryptogamous Plants found growing wild in Jefferson county, Indiana, to which is added a list of plants growing in Clark county, but not found in Jefferson, by John F. Baird. 8 vo.: pp. 9. (?)

Barnes, C. R., Brotherus, Dr., Venturi, Dr. v., Renauld, F., Cardot, J., Röhl, J., Stephani, F. Nord-Amerikanische Laubmoose, Torfmoose und Lebermoose gesammelt von Dr. Julius Röhl in Darmstadt. Hedwigia, 32: 181-203, 260-309, 334-402. (1893.)

Includes species collected at Hobart, Indiana: 19 Musci, 9 Sphagnaceae, 5 Hepaticae, with several new varieties.

Benedict, A. C., and Elrod, M. 'N. A partial list of the Flora of Wabash and Cass counties, with notes. 17th Ann. Rept. Geol. Survey, 260-272. (1892.)

List of 92 plants.

Blatchley, W. S. On Weeds in general, and our worst weeds in particular. *Indiana Farmer*. (8 March, 1890.)

Includes list of 20 worst weeds of Indiana, and some account of their origin in the state.

———**The Ironweed.** *Indiana Farmer*. (4 October, 1890.)

Discusses habits and general character as a weed.

Bolley, H. L. The Heterocismal Pucciniæ. *Am. Month. Micros. Jour.*, 10: 169-180, plate. (1889.)

Illustrates *Puccinia Bolleyana* and gives account of the change of host plants for several species.

———**Sub-epidermal Rusts.** *Bot. Gazette*, 14: 139-145. Pl. 15. (June, 1889.)

Notes on various Indiana species of *Puccinia*.

———**Wheat Rust.** *Bull. Ag. Exp. Sta.*, No. 26. (July, 1889.)

Account of *Puccinia graminis*, *P. coronata*, *P. rubigo-vera*.

Botanical Gazette. Some Big Trees of Indiana. *Bot. Gazette*, 5: 69-70. (May, 1880.)

Quotes notes from Case's Botanical Index.

———**Notice of Catalogue of the Flora of Indiana.** *Bot. Gazette*, 6: 179. (Jan. 1881.)

Note to effect that work through Compositæ was done by C. R. Barnes, and that remaining work was to be done by editors.

———**Flora of Indiana.** Supplement I. (April, 1882), pp. 1-4.

List of 43 additions, bringing the number of vascular plants of Indiana to 1,475.

———**New Indiana Plants.** *Bot. Gazette*, 8: 285. (Aug. 1883.)

Notes four additions to the state flora.

Bowers, Homer. A contribution to the life history of *Hydrastis Canadensis*. *Bot. Gazette*, 16: 73-82. Pl. 8. (March, 1891.)

Notes on life history and probable extinction of the species in Indiana.

Bradner, E. A partial Catalogue of the Flora of Steuben county. 17th Ann. Rept. Geol. Survey, 135-159. (1892.)

List of 729 species.

Collins, S. H. A partial flora of Dearborn county, Indiana, and vicinity. 16th Ann. Rept. Dept. of Geology and Natural History, 376-382. (1889.)

List of 248 species.

Oopeland, Herbert E. *Cyclostoma platyphyllum* Moquin. Bot. Bulletin (now Bot. Gazette), 1: 6. (Dec. 1875.)

Notes this plant as established on Fall creek. Also, *Nasturtium sessiliflorum* and *Dicelyloctenium Aegyptiacum* in Indianapolis.

Coulter, John Merle. *Sullivantia Ohionis*. Amer. Nat., 9: 572. (1874.)

Its occurrence near Hanover, with some account of its habitat.

——Partial list of the flora of Jefferson county. 6th Ann. Rept. Geol. Survey, 229-277. (1875.)

List of 722 species.

——*Aster Novae-Angliae*. Bot. Bulletin (now Bot. Gazette), 1: 2. (Nov. 1875.)

Notes on habits of plants growing in vicinity of Hanover.

——(*Querci* near Hanover, Ind. Bot. Bull., 1: 2. (Nov. 1875.)

Mentions nine species in vicinity.

——*Diarrhena Americana* Beauv. Bot. Bull., 1: 6. (Dec. 1875.)

Notes occurrence of this plant in Clifty Ravine.

——*Dentaria laciniata* Muhl. Bot. Bull., 1: 8. (Dec. 1875.)

Notes variations of this plant in vicinity; suggest union of several species of *Dentaria* under one name.

——An interesting herbarium. Bot. Bull., 1: 9-10. (Jan. 1876.)

Account of the collection of Dr. Clapp, who collected in vicinity of New Albany, 1835-6, then preserved by the Natural History Society of that place.

——Some effects of the unusual season. Bot. Bull., 1: 11-12. (Jan. 1876.)

Notes blossoming of various plants in December, 1875, in various parts of state.

——Some plants noted in Carroll county, Indiana. Bot. Bull., 1: 12. (Jan. 1876.)

Notes richness of flora of Wabash valley.

——Some early plants. Bot. Bull., 1: 15. (Feb. 1876.)

Notes early blossoming of plants, January, 1876.

——*Uromyces lespedezae* (Schw.) Bot. Bull., 1: 20. (March, 1876.)

Notes occurrence of this rust as plentiful on *L. violacea*. Quotes letter from C. H. Peck, naming the fungus, which seems to have been the first collected in the state of which we have any definite record.

——Some plants new to the Flora of Jefferson county. Bot. Bull., 1: 34-35. (June, 1876.)

Notes on the occurrence of numerous plants not included in the two lists of the Geol. Survey.

——Plants new to Jefferson county. Bot. Bull., 1: 38. (July, 1876.)

Additional list collected by A. H. Young.

——Some *Carices* near Hanover, Ind. Bot. Bull., 1: 38-40. (July, 1876.)

List of 24 species, with notes.

——The "Knobs" of Southern Indiana. Bot. Bull., 1: 41-42. (August, 1876.)

Brief account of the flora of this region in Clark and Floyd counties.

- Magnolia acuminata** L. Bot. Bull., 1: 44. (August, 1876.)
Notes on this species near Hanover, Ind.
- Conobea multifida** Benth. Bot. Bull., 1: 47. (Sept. 1876.)
Notes on this species from Kirkville, Ind.
- Some river bank flowers.** Bot. Bull., 1: 51-52. (Oct. 1876.)
Notes on plants growing in the alluvium of the Ohio river near Hanover, Ind.
- Aster oblongifolius** Nutt. Bot. Gazette, 2: 65-66. (Dec. 1876.)
Notes occurrence in Jefferson county.
- Natural grafting.** Bot. Gazette, 2: 137. (Sept. 1877.)
Notes *Carpinus* growing on trunk of *Fagus* near Hanover.
- Spermacoce glabra** Michx. Bot. Gazette, 2: 137-138. (Sept. 1877.)
Note of station near Hanover.
- The "Barrens" of Southern Indiana.** Bot. Gazette, 2: 145-146. (Oct. 1877.)
Brief account of the flora of these regions, located in Clark, Floyd, Washington and Harrison counties.
- Some new stations.** Bot. Gazette, 3: 24. (March, 1878.)
Notes on rare plants of Clark county.
- The Flora of Northern Indiana.** Bot. Gazette, 4: 109-113. (Jan. 1879.)
Notes based largely on a botanizing trip along the L. S. & M. S. R. R.
- A natural Botanic Garden.** Bot. Gazette, 5: 70. (May, 1880.)
Notes on flora of Wabash College campus.
- A comparative view of the Flora of Indiana.** Bot. Gazette, 6: 301-302. (Dec. 1881.)
Gives comparative statistics of the flora of Indiana, Washington, D. C., and eastern United States.
- Some Notes on Physostegia Virginiana.** Bot. Gazette, 7: 111-112. (Sept. 1882.)
Notes the flowers as cataleptic.
- Coulter, J. M., Coulter, M. S., and Barnes, C. R.** Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Indiana. 8 vo. pp. 38. Crawfordsville (1881.)
List of 1,432 species.
- Coulter, John M., and Thompson, Harvey.** Origin of the Indiana Flora. 15th Ann. Rept. Geol. Survey, 253-282. (1886.)
- Coulter, [M.] Stanley.** On the size of forest trees in Jefferson county, Ind. Bot. Bull. 1: 10. (Jan., 1876.)
Notes large trees, especially *Platanus occidentalis*, *Fagus ferruginea* and *Liriodendron Tulipifera*.

——The numerical relations existing among the forest trees of Jefferson county, Ind. Bot. Bull., 1: 15. (Feb. 1876.)

Gives relative abundance in per cents: *Fagus ferruginea* leads with 35 per cent.

——The forest trees of Cass County, Ind. Bot. Bull., 1: 42-43. (Aug. 1876.)

Notes on relative abundance; the *Querri* forming 50 per cent.

——Note on *Euphorbia marginata*. Bot. Gazette, 2: 63. (Dec. 1876.)

Note on naturalization of this plant on Eel river.

——The Forest Trees of Indiana, their distribution and economic value. Trans. Indiana Horticultural Society, 1891, 157-192 (1892.) Also, separate pp. 36.

List of 108 species, with notes on distribution and economic characters.

Curtiss, George L. Diatoms of the waters of Indiana. 12th Ann. Rept. Geol. Survey, 377-384, Pl. 33-38. (1883.)

Figures numerous species of Diatoms: a few of the figures named.

Elliott, Thomas B. The trees of Indiana. Trans. Indianapolis Acad. Science, 72-86. (1872.)

[Not seen; inserted on authority of Dr. N. L. Britton's State and Local Floras.]

Geddes, W. N. Some great ragweeds. Bot. Bull., 1: 14-15. (Feb. 1876.)

Notes *Ambrosia trifida* 12 to 18 feet high near Hanover.

Gorby, S. S. Geology of Miami county. 16th Ann. Rept. Dept. of Geology and Natural History, 165-188. (1889.)

Includes list of trees and shrubs, pp. 168-170.

Grahn, E. G. Microscopical Notes. Bull. Brookville Soc. Nat. Hist., No. I., 39-41. (1885.)

List of 46 Diatomaceæ and 2 Desmidiaceæ from vicinity of Brookville.

Haines, Mary P. List of Ferns, Mosses, Hepaticæ and Lichens collected in Wayne county. 8th, 9th and 10th Ann. Rept. Geol. Survey, 235-239. (1879.)

Higley, William K. and Radden, Charles S. The flora of Cook county, Illinois, and a part of Lake county, Indiana. Bull. Chicago Acad. Sci. II: i-xxiii, 1-168, with map.

Phanerogams and Pteridophytes of Lake county north of the Little Calumet river.

Hill, E. J. Botanical Notes. Bot. Gazette, 6: 259-263. (Sept. 1881.)

Localities for various plants in Northern Indiana.

——*Eleocharis dispar* n. sp. Bot. Gazette, 7: 3. (Jan. 1882.)

From Lake county; referred by Gray's Manual to *E. capitata* R. Br.

——Notes on Indiana Plants. Bot. Gazette, 7: 187-188. (March, 1882.)

Gives stations of new plants from Lake county.

- Notes on Indiana Plants, 1883. Bot. Gazette, 9: 45-48. (March, 1884.)
Various Lake county stations.
- Some Indiana Plants. Bot. Gazette, 10: 262-263. (April, 1885.)
Stations in Lake and Porter counties.
- Some Indiana Plants. Bot. Gazette, 13: 323. (Dec. 1888.)
Notes on certain plants of the northern counties.
- Notes on the Flora of Chicago and vicinity. Bot. Gazette, 17: 246-252. (August, 1892.)
Notes on a few Lake county species.
- Hussey, John.** Regular flower in *Pedicularis Canadensis*. Bot. Gazette, 4: 166-167. (June, 1879.)
Note on form, from near Lafayette.
- Lapham, Increase A.** The Grasses of Wisconsin and the adjacent states of Iowa, Illinois, Indiana, Ohio and Michigan, and the territory of Minnesota and the region about Lake Superior. Trans. Wis. State Ag. Soc., 3: 397-488. (1853.)
- Maximilian, Alexander Philip** (Prince of Neuwied). [List of trees in vicinity of New Harmony.] Reise in das innere Nord-Amerika, 1: 209, (Coblenz, 1839.)
Includes list of 60 species of trees.
- Meyncke, O. M.** A large red-bud. Bot. Gazette, 7: 36. (March, 1882.)
Tree 14 inches in diameter near Brookville.
- The Flora of Franklin county. Bull. Brookville Soc. Nat. Hist., No. 1: 13-38 (1885); No. 2: 45-49 (1886).
- Phinney, A. J.** Catalogue of the Flora of Central Eastern Indiana. (Alpine or elevated district of the State.) 12th Ann. Rept. Geol. Survey, vey, 196-243. (1883.)
Mainly from Delaware and Wayne counties.
- Riddell, John L.** Synopsis of the Flora of the Western States. Western Journ. of Med. and Phys. Sciences, 7: 329-374 (Jan. 1835); 489-556 (April, 1835.)
Intended to cover Ohio, Indiana, Illinois, West Tennessee, Missouri and Northwest Territories.
List of 1,802 species, including mosses, hepaticæ and lichens.
- Ridgway, Robert.** Notes on the Native Trees of the Lower Wabash and White river valleys in Illinois and Indiana. Proc. U. S. Nat. Mus., -: 49-88. (1882.)
Valuable notes on 92 species of trees.
- Additions and corrections to the list of native trees of the Lower Wabash. Bot. Gazette, 8: 345-352. (Dec. 1883.)

Rose, Joseph N. Nostoc and Penicillium in $\text{Na C}_2 \text{H}_3 \text{O}_2$. Bot. Gazette, 10: 280. (May, 1885.)

Note on occurrences of these plants in a four per cent. solution of sodium acetate.

——Notes on the conjugation of Spirogyra. Bot. Gazette, 10: 304-306, Pl. 7. (July, 1885.)

Diverse methods of conjugation studied at Wabash College.

——Mildews of Indiana. Bot. Gazette, 11: 60-63. (March, 1886.)

Enumerates 12 species of Erysiphe.

——Selinum Canadense in Indiana. Bot. Gazette, 11: 338. (Dec. 1886.)

Notes discovery of station of this plant near Crawfordsville.

Schneck, J. Flora of the Lower Wabash valley, below the mouth of the White river. 7th Ann. Rept. Geol. Survey, 504-579. (1876.)

List of 867 species, some of which belong to the flora of Illinois.

——Some plants of the Lower Wabash. Bot. Gazette, 2: 83. (Feb. 1877.)

26 plants added to his previous list.

Thompson, Maurice. Geographical Botany. 15th Ann. Rept. Geol. Survey, 242-252. (1886.)

Introduction to paper by Coulter and Thompson.

——Preliminary sketch of the characteristic plants of the Kankakee region. 16th Ann. Rept. Dept. of Geol. and Nat. Hist., 155-161. (1889.)

Brief list of a few common plants.

——Geological and Natural History Report of Carroll county. 17th Ann. Rept. Geol. Survey, 171-191. (1892.)

Contains a partial list of plants, pp. 188-190.

Thompson, Harvey. Origin of the Flora of Indiana. Bot. Gazette, 11: 88-90. (April, 1886.)

Resumé of longer article, by Coulter and Thompson.

Troop, J. Grasses of Indiana. Bull. Ag. Exp. Sta., No. 29. (Dec. 1889.)

Descriptions of 128 grasses known to inhabit Indiana, with figures of several.

Underwood, Lucien Marcus. Some Additions to the state Flora from Putnam county. Proc. Ind. Acad. Sci., 1891, 89-91. (1892.)

Notes on *Eustichia Norvegica*, *Fossombronia cristata*, *Trametes ambigua*, *Hydnum stratosum*, *Cordyceps capitata*, *Phallus Ravenelii*.

——Edible Fungi.—A great waste of vegetable food in Indiana. Trans. Indiana Hort. Soc., 1893, 62-67. (1894.)

Popular account of the most common edible species, with plate.

Van Gorder, W. B. Catalogue of the Flora of Noble county, Indiana. Pp. 52. Kendallville, Ind. (1885.)

List of 633 species, 25 of which are not in state catalogue of 1881.

Young, A. Harvey. Manual of the Botany of Jefferson county. 2nd Ann. Rept. Geol. Survey, 253-292. (1871.)

List of 609 species.

——Notes on certain species of the genus *Asplenium*. Bot. Bull., 1: 2-3. (Nov. 1875.)

Notes on four species of Southern Indiana.

——Notes on some interesting plants found in Jefferson county. Bot. Bull., 1: 6-8. (Dec. 1875.)

Notes occurrence and stations of several rare plants.

——Notes upon some Gramineæ. Bot. Bull., 1: 18-20. (March, 1876.)

Notes based on collections in Jefferson county.

——Ferns near Hanover, Ind. Bot. Bull., 1: 22-23, 27. (April, May, 1876.)

Notes on habitat of twenty species of ferns.

——Bryological Notes. Bot. Gazette, 2: 61-62. (Dec. 1876.)

Includes list of 69 species from Southern Indiana, chiefly near Hanover.

——*Jeffersonia diphylla* Pers. Bot. Gazette, 2: 136-137. (Sept. 1877.)

Notes on variations.

——*Habenaria peramœna* Gray. Bot. Gazette, 2: 137. (Sept. 1877.)

Notes abundance near Hanover.

——*Monotropa uniflora*. Bot. Gazette, 3: 37-38. (April, 1878.)

Notes station in Jefferson county, and poisonous effect: cf. Bot. Gazette, 3: 54-55 and 79, on latter point.

UNPUBLISHED PAPERS READ BEFORE THE ACADEMY.

Blatchley, W. S. List of the plants of Monroe county, Ind. (Read, 1888.)

Paper accessible; many of the plants are in the herbarium of DePauw University.

——The Compositæ of Vigo county, Ind. (Read, 1889.)

Paper accessible.

——On some plants new to the state list. (Read, 1889.)

Paper accessible; many of the plants are in the herbarium of DePauw University.

Brannon, M. A. Some Indiana Mildews. (Read, 1889.)

Paper in the hands of the survey, also duplicates of many of the specimens.

Evans, Walter H. Lichens of Indiana. (Read, 1887.)

Paper not accessible; specimens ought to be at Wabash College, but cannot be found.

Fisher, E. M. Parasitic Fungi of Indiana. (Read, 1890.)

Paper not accessible; plants were collected for Div. of Veg. Pathology, U. S. Dept. Agriculture. Through the kindness of Prof. B. T. Galloway, a list of species collected is in possession of the survey.

Hubbard, G. O. Additions to the Flora of Indiana. (Read, 1886 and 1887.)

Papers not accessible as read; a complete list of plants collected by Mr. Hubbard in Indiana is in the possession of the survey.

MacDougal, Daniel T. The plants of Putnam county. (Read, 1889.)

Paper in the hands of the survey; most of the plants it represents are in the herbarium of DePauw University.

Meyncke, O. M. Notes on the White-spored Agarics of Franklin county, Ind. (Read, 1887.)

Paper not accessible; plants represented by the notes not preserved.

Mikels, Rosa Redding. Preliminary paper on the flora of Henry county, Ind. (Read, 1891.)

Paper accessible; few plants to represent the flora preserved.

Shannon, W. P. The Occurrence of *Veratrum Woodii* in Decatur county, Ind. (Read, 1890.)

Spillman, W. J. Preliminary list of Knox county plants. (Read, 1890.)

Paper not accessible; a list of Knox county plants in the herbarium of the writer is in the hands of the survey.

APPENDIX B.

LIST OF CRYPTOGRAMS AT PRESENT KNOWN TO INHABIT THE STATE OF INDIANA.

In the following list specimens collected by various persons are duly credited; where no collector is named, the collection was made by the Director of the Survey. The plants collected by Mr. Fisher are in the U. S. Nat. herbarium; a few of these have not been collected by any one else. Unless a special statement is made, all species are represented in the Underwood herbarium; reference is made in brackets for those species not in our possession. A considerable amount of material including some interesting algae has not been fully determined as yet, and some small collections have not been worked over.

MYXOMYCETES.

ARCYRIA CINEREA (Bull.) Schum. Vermillion, 7, 1889 (Arthur).

ARCYRIA PUNICEA Pers. Vermillion, 7, 1889 (Arthur); Putnam, 10, 1893.

BADHAMIA UTRICULARIS (Bull.) Berk. Putnam, 10, 1893.

CERATIONMYXA MUCIDA (Pers.) Schröt. (*Ceratium hydroides* Auct.) Vigo, 5, 1893.

COMATRICHA LONGA Pk. Putnam, 7, 1893.

DICTYDIUM LONGIPES Morg. Vermillion, 9, 1889 (Arthur).

DIDYMIUM FARINACEUM Schrad. Putnam, 5, 1892.

DIDYMIUM MICROCARPUM (Fr.) Rost. Putnam, 3, 1894.

FULIGO SEPTICA (Link.) Gmel. Vermillion, 7, 1889 (Arthur); Putnam, 7, 1893.

HEMIARCYRIA CLAVATA (Pers.) Rost. Putnam, 10, 1892.

HEMIARCYRIA PLUMOSA Morg. Vermillion, 7, 1889 (Arthur).

HEMIARCYRIA RUBIFORMIS (Pers.) Rost. Vermillion, 7, 1889 (Arthur); Putnam, 10, 1892.

LAMPRODERMA VIOLACEUM (Fr.) Rost. Putnam, 10, 1893.

LYCOGALA EPIDENDRUM Buxb. Putnam, 5, 1890 (Arthur); 10, 1891; 10, 1893.

LYCOGALA FLAVO-FUSCUM (Ehrenb.) Rost. Putnam, 11, 1893.

STEMONITIS FERRUGINEA Ehrh. Vermillion, 7, 1889 (Arthur). [Herb. Arthur.]

STEMONITIS FUSCA Roth. Vermillion, 7, 1889 (Arthur).

STEMONITIS NIGRESCENS Rex. Putnam, 10, 1893.

TRICHIA SCABRA Rost. Tippecanoe, 2, 1892 (Arthur); Putnam, 10, 1892.

TRICHIA VARIA Pers. Putnam, 10, 1891; 10, 1892; 10, 1893.

TUBULINA CYLINDRICA (Bull.) D C. Vermillion, 7, 1889 (Arthur).

PHYCOMYCETES.

SYNCHITRICEÆ.

SYNCHITRIUM DECIPIENS Farl.

On *Amphicarpæa monoica*, Putnam, 9, 1893; Johnson, 9, 1890, (Fisher).

SYNCHITRIUM FULGENS Schröt.

On *Enothera biennis*, Brown, 5, 1893.

MUCORACEÆ.

MUCOR STOLONIFER Ehrhenb.

On bread, Putnam, 1891.

ENTOMOPHTHORACEÆ.

EMPUSA MUSCÆ Cohn.

On flies, Putnam, 10, 1893.

PERONOSPORACEÆ.

ALBUGO AMARANTHI (Schw.) Kuntze. (*Cystopus bliti*).

On *Amarantus* sp., Putnam, 10, 1892; Tippecanoe, 7, 1890 (Bolley).

On *Amarantus chlorostachys hybridus*, Johnson, 7, 1890 (Fisher).

On *Amarantus retroflexus*, Johnson, 7, 1890 (Fisher).

On *Amarantus spinosus*? Montgomery, 1893 (Olive).

ALBUGO CANDIDUS (Pers.) Kuntze. (*Cystopus candidus*).

On *Sisymbrium officinale*, Brown, 5, 1893; Putnam, 7, 1893.

- On *Capsella bursa-pastoris*, Putnam, 4, 1892; Montgomery, 1893 (Olive).
 On Radish, Putnam, 9, 1891; Johnson, 8, 1890 (Fisher).
 On *Sisymbrium canesceus*, Putnam, 5, 1893.
 On *Brassica nigra*, Johnson, 7, 1890 (Fisher); Tippecanoe, 8, 1891 (Arthur).
 On *Brassica alba*, Johnson, 7, 1890 (Fisher).
 On *Lepidium Virginicum*, Montgomery, 1893 (Olive); Putnam, 4, 1894.
 On *Dentaria* sp., Montgomery, 1893 (Olive).
- ALBUGO IPOMOEAE-PANDURAE (Schw.) Swingle.**
 On *Ipomœa hederacea*, Putnam, 9, 1893.
 On *Ipomœa pandurata*, Johnson, 9, 1890 (Fisher).
- ALBUGO PORTULACAE (D C.) Kuntze.**
 On *Portulaca oleracea*, Putnam, 6, 1893; Johnson, 8, 1890 (Fisher);
 Montgomery, 1893 (Olive); Tippecanoe 7, 1890 (Bolley).
- PLASMOPARA AUSTRALIS (Speg.) Swingle.**
 On *Sicyos angulatus*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]
- PLASMOPARA GERANII (Pk.) Berl. et De Toni.**
 On *Geranium Carolinianum*, Putnam, 5, 1892; Vigo, 5, 1893.
- PLASMOPARA HALSTEDII (Farl.) Berl. et De Toni.**
 On *Bidens connata*, Johnson, 9, 1890 (Fisher).
 On *Bidens frondosa*, Johnson, 8, 1890 (Fisher).
 On *Helianthus annuus*, Montgomery, 1893 (Olive).
- PLASMOPARA OBducens Schröt.**
 On *Impatiens* sp., Putnam, 4, 1892.
 On *Impatiens pallida*, Tippecanoe, 5, 1893 (Arthur).
- PLASMOPARA VITICOLA (B. and C.) Berl. et De Toni.**
 On *Vitis cordifolia*, Johnson, 7, 1890 (Fisher).
 On *Vitis* (sp. cult.), Johnson, 9, 1890 (Fisher); Montgomery, 1893 (Olive).
 Putnam, 7, 1893; Crawford, 9, 1889 (Arthur).
- PERONOSPORA ALTA Fckl.**
 On *Plantago major*, Johnson, 7, 1890 (Fisher); Putnam, 5, 1894.
- PERONOSPORA CORYDALIS De Bary.**
 On *Dicentra Canadensis*, Putnam, 4, 1892; 4, 1893.
 On *Dicentra cucullaria*, Montgomery, 1893 (Olive).
- PERONOSPORA EFFUSA (Grev.) Rabenh.**
 On *Chenopodium* sp., Putnam, 9, 1891.
 On *Chenopodium album*, Johnson, 9, 1890 (Fisher).
- PERONOSPORA FICARIE Tul.**
 On *Ranunculus* sp., Putnam, 4, 1893.

On *Ranunculus recurvatus*, Montgomery, 1893 (Olive).

PERONOSPORA RUMICIS Corda.

On *Polygonum dumetorum scandens*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]

ASCOMYCETES.

DISCOMYCETES.

CHLOROSPLENUM AERUGINOSUM (Oeder.) De Not. Putnam, 12, 1893.

HELOTIUM CITRINUM (Hedw.) Fr. Putnam, 10, 1892; 7, 1893; 10, 1893.

PEZIZA COCCINEA Jacq. Putnam, 5, 1893.

PEZIZA OCCIDENTALIS Schw. Vigo, 5, 1893; Bown, 5, 1893.

PEZIZA SCUTELLATA L. Putnam, 5, 1893.

PSILOPEZIA NUMMULARIS Berk. Putnam, 10, 1893.

URNULA CRATERIUM (Schw.) Fr. Tippecanoe, 4, 1892; Montgomery, 4, 1892; Putnam, 5, 1892; 5, 1893; Vigo, 5, 1893.

RHYTISMA ACERINUM (Pers.) Fr.

On *Acer saccharinum* (*A. dasycarpum*) Putnam, 10, 1891; 10, 1893; Marshall, 10, 1893.

RHYTISMA ANDROMEDAE (Pers.) Fr.

On *Andromeda polifolia*, Fulton, 10, 1893.

RHYTISMA PRINI (Schw.) Fr.

On *Ilex verticillata*, Marshall, 10, 1893; Vigo, 10, 1893.

GYROMITRA BRUNNEA n. sp. A stout, fleshy, stipitate plant, 8-13 cm. high, bearing a broad, much contorted, brown ascoma; stem 2-5 cm. thick, more or less enlarged and spongy-solid at the base, hollow below, rarely slightly fluted, clear white; receptacle 5-12 cm. across in the widest direction, the two diameters usually considerably unequal, irregularly lobed and plicate, in places faintly marked into areas by indistinct anastomosing ridges, closely cohering with the stem in various parts, rich chocolate brown or somewhat lighter if much covered with the leaves among which it grows, whitish underneath; asci 8-spored; spores oval, 28-30 mic. long by about 14 wide, hyaline, somewhat roughened-tuberculate, usually nucleate, the highly refractive nucleus spherical or oval, 11 mic. or if oval 14 by 11 mic. in diameter; paraphyses slender, enlarged at the apex, faintly septate. In rich woods, mostly in beech leaf mould; Putnam county, May 1892, 1893 and 1894, first found by Dr. W. V. Brown. The plant is esculent, tender and possesses a fine flavor. Often as many as 8 or 10 plants would be found in one small area but the plant appears to be local

and never very abundant. Some single plants would weigh nearly half a pound.

MORCHELLA ESCULENTA (L.) Pers. Putnam, 4, 1892; 5, 1893.

MORCHELLA RIMOSIPES D C. Putnam, 4, 1892.

MORCHELLA HYBRIDA (Sow.) Pers. (*M. semilibera* D C.) Putnam, 4, 1892.

MORCHELLA CONICA Pers. Putnam, 5, 1893.

GYMNOASCHEE.

EXOASCUS DEFORMANS (Berk.) Fckl.

On peach leaves, Putnam, 5, 1892; Vigo, 5, 1893; Monroe, 5, 1893; Montgomery, 1893 (Olive); Tippecanoe 6, 1890 (Bolley).

EXOASCUS POTENTILLÆ Farl.

On *Potentilla Canadensis*, Vigo 5, 1893; Putnam, 5, 1893.

EXOASCUS PRUNI (Tul.) Fckl.

On *Prunus Americana*, Monroe, 5, 1893.

EXOASCUS sp.

On *Ostrya Virginica*, Putnam, 5, 1893; Vigo, 5, 1893.

LICHENES.

ARTHONIA SPECTABILIS Fl. Putnam, 5, 1893.

BUELLIA PARASINA (Ach.) Th. Fr. Putnam, 5, 1893.

CLADONIA CESPITICIA (Pers.) Fl. Putnam, 5, 1893.

CLADONIA FIMBRIATA (L.) Fr. Putnam, 5, 1893.

CLADONIA FURCATA (Hud.) Fr. Putnam, 5, 1893.

CLADONIA MITRULA Tuck. Putnam, 5, 1893.

CLADONIA PYXIDATA (L.) Fr. Putnam, 4, 1893.

CLADONIA SYMPHYCARPA Fr. Putnam, 4, 1893.

ENDOCARPON MINIATUM Fr. Owen, 5, 1893; 10, 1893.

GRAPHIS SCRIPTA Fr. Putnam, 10, 1891.

LECANORA PALLIDA (Schreb.) Schær. Putnam, 5, 1893.

LECANORA SUBFUSCA (L.) Ach. Putnam, 5, 1893.

LECANORA TARTAREA (L.) Ach. Putnam, 5, 1893.

LECIDEA ALBOCERULESCENS (Wulf.) Schoen. Putnam, 5, 1893.

NEPHROMA HELVETICUM Ach. Putnam, 5, 1893.

NEPHROMA LEVIGATUM Ach. Putnam, 5, 1893.

PARMELIA CAPERATA (L.) Ach. Putnam 4, 1893.

PARMELIA COLPODES (Ach.) Nyl. Putnam, 5, 1893.

PARMELIA PERFORATA (Jacq.) Ach. Putnam, 5, 1893.

PARMELIA SAXATILIS (L.) Fr. Putnam, 4, 1893.

PARMELIA TILIACEA (Hoffm.) Floerk. Putnam, 5, 1893.

- PELTIGERA CANINA** (L.) Hoffm. Putnam, 5, 1893.
PERTUSARIA COMUNE D C. Putnam, 5, 1893.
PERTUSARIA VELATA (Turn.) Nyl. Putnam, 5, 1893.
PHYSCIA STELLARIS (L.) Tuck. Putnam, 10, 1891.
RAMALINA CALICARIS (L.) Fr. Putnam, 4, 1892.
STICTA AMPLISSIMA (Scop.) Mass. Putnam, 5, 1893.
STICTA PULMONARIA (L.) Ach. Putnam, 10, 1891; Owen, 10, 1893.
THELOCHISTES CONCOLOR (Dicks.) Tuck. Putnam 10, 1891.
USNEA BARBATA (L.) Fr. Putnam, 5, 1893; Brown, 5, 1893; Owen, 5, 1893;
 Marshall, 10, 1893.

PERISPORIACEÆ.

ERYSIPHE CICHORACEARUM D C.

- On **Actinomeris squarrosa**, Johnson, 10, 1890 (Fisher).
 On **Ambrosia artemisiifolia**, Johnson, 8, 1890 (Fisher); Marshall, 10, 1893; Montgomery, 1893 (Olive).
 On **Ambrosia trifida**, Johnson, 8, 1890 (Fisher); Montgomery (Brannon, Olive); Putnam, 10, 1891.
 On **Aster cordifolius**, Johnson, 10, 1890 (Fisher).
 On **Aster Novæ-Angliæ**, Johnson, 9, 1890 (Fisher).
 On **Aster paniculatus**, Johnson, 10, 1890 (Fisher); Montgomery, 1893 (Olive).
 On **Aster puniceus**, Johnson, 11, 1890 (Fisher).
 On **Aster Tradescanti**, Johnson, 10, 1890 (Fisher).
 On **Aster ericoides**, Montgomery, 1893 (Olive).
 On **Aster azureus**, Montgomery, 1893 (Olive).
 On **Aster** (sp.), Montgomery (Brannon).
 On **Cnicus altissimus**, Montgomery, 10, 1890 (Fisher).
 On **Eupatorium perfoliatum**, Fulton, 10, 1893; Johnson, 10, 1890 (Fisher); Montgomery, 1893 (Olive).
 On **Eupatorium purpureum**, Johnson, 8, 1890 (Fisher).
 On **Helianthus annuus**, Putnam, 11, 1892.
 On **Helianthus decapetalus**, Montgomery, 10, 1890 (Fisher).
 On **Helianthus parviflorus**, Tippecanoe, 10, 1892 (Arthur).
 On **Helianthus tuberosus**, Montgomery, 10, 1890 (Fisher).
 On **Hydrophyllum appendiculatum**, Montgomery, 10, 1890 (Fisher); 1893 (Olive).
 On **Hydrophyllum Virginicum**, Montgomery, 10, 1893; 1893 (Olive).

On *Hydrophyllum macrophyllum*, Putnam, 7, 1893; Montgomery, 1893 (Olive).

On *Parietaria Canadensis*, Montgomery, 7, 1890 (Fisher).

On *Phlox paniculata*, Montgomery 10, 1890 (Fisher).

On *Solidago Canadensis*, Montgomery, 10, 1890 (Fisher); 1893 (Olive); Johnson, 9, 1890 (Fisher).

On *Solidago serotina*, Johnson, 10, 1890 (Fisher).

On *Solidago latifolia*, Montgomery, 1893 (Olive).

On *Verbena hastata*, Marshall, 10, 1893.

On *Verbena stricta*, Johnson, 7, 1890 (Fisher); Montgomery, 10, 1893 Tippecanoe, 9, 1888 (Bolley).

On *Verbena urticæfolia*, Johnson, 11, 1890 (Fisher); Putnam, 10, 1891 Montgomery, 1893 (Olive).

On *Vernonia fasciculata*, Putnam, 10, 1891; Montgomery 10, 1893.

On *Vernonia Noveboracensis*, Johnson, 8, 1890 (Fisher).

On *Xanthium strumarium*, Johnson, 10, 1890 (Fisher); Putnam, 9, 1891; Montgomery 1893 (Olive).

On *Zinnia elegans*, Putnam, 10, 1891.

On *Pilea pumila*, Montgomery, 1893 (Olive).

ERYSIPHE COMMUNIS (Wallr.) Fr.

On *Amphicarpæa monoica*, Johnson, 9, 1890 (Fisher); Putnam, 9, 1893; Vigo, 10, 1893.

On *Apios tuberosa*? Johnson, 9, 1890 (Fisher).

On *Aquilegia Canadensis*, Owen, 10, 1893.

On *Clematis Virginiana*, Putnam, 10, 1891; Johnson, 9, 1890 (Fisher); Montgomery, 9, 1889 (Brannon).

On *Geranium maculatum*, Johnson, 8, 1890 (Fisher).

On *Heuchera Americana*, Putnam, 10, 1891.

On *Ranunculus abortivus*, Johnson, 7, 1890 (Fisher); Putnam, 7, 1893 10, 1891; Montgomery, 1893 (Olive).

On *Lathyrus palustris*, Marshall, 10, 1893.

On *Thalictrum polygamum*, Johnson 10, 1890 (Fisher).

On *Ranunculus recurvatus*, Montgomery, 1893 (Olive).

ERYSIPHE GALEOPSISIS, D C.

On *Chelone glabra*, Johnson, 10, 1890 (Fisher).

On *Scutellaria lateriflora*, Johnson, 10, 1890 (Fisher); Marshall, 10, 1893 Putnam, 10, 1891; Montgomery, 1893 (Olive).

On *Scutellaria pilosa*, Johnson, 10, 1890 (Fisher).

On *Stachys aspera*, Johnson, 10, 1890 (Fisher); Fulton, 10, 1893.

ERYSIPHE GRAMINIS D C.

On *Poa pratensis*, Johnson, 11, 1890 (Fisher); Montgomery, 1893 (Olive).

On lawn grass, Putnam, 9, 1891; 11, 1891.

ERYSIPHE LIRIODENDRI Schw.

On *Liriodendron tulipifera*, Putnam, 10, 1891; 10, 1893; Montgomery, 10, 1893; Wabash, 10, 1891 (Miller).

MICROSPHERA ALNI (D C.) Wint.

On *Betula pumila*, Fulton, 10, 1893 (Fisher).

On *Carpinus Caroliniana*, Johnson, 9, 1890 (Fisher); Montgomery (Brannon).

On *Fagus ferruginea*, Johnson, 9, 1890 (Fisher).

On *Ilex verticillata*, Marshall, 10, 1893.

On *Hicoria sulcata*, Johnson, 9, 1890 (Fisher); Marshall, 10, 1893.

On *Euonymus atropurpureus*, Johnson, 10, 1890 (Fisher).

On *Juglans nigra*, Johnson, 9, 1890 (Fisher); Putnam, 10, 1893.

On *Platanus occidentalis*, Johnson, 9, 1890 (Fisher); Putnam, 10, 1891; Montgomery, 1893 (Olive).

On *Syringa vulgaris*, Johnson, 10, 1890 (Fisher); Putnam, 7, 1893; Tippecanoe, 10, 1893 (Arthur); Montgomery, 1893 (Olive).

On *Ostrya Virginiana*, Johnson, 10, 1890 (Fisher).

On *Tecoma radicans*, Putnam, 10, 1893.

On *Viburnum acerifolium*, Putnam, 10, 1891.

On *Viburnum dentatum*, Johnson, 10, 1891 (Fisher).

On *Viburnum prunifolium*, Johnson, 9, 1890 (Fisher).

On *Viburnum pubescens*, Putnam, 10, 1891.

MICROSPHERA DIFFUSA C. and P.

On *Lespedeza* sp., Marshall, 10, 1893.

MICROSPHERA ELEVATA Burrill.

On *Catalpa*, Putnam, 10, 1891; 10, 1893; Owen, 10, 1893; Tippecanoe, 9, 1890 (Bolley).

MICROSPHERA ERINEOPHILA Pk.

On Erineum of *Fagus ferruginea*, Marion, 8, 1890 (Tracy); Putnam, 10, 1891; 10, 1893.

MICROSPHERA EUPHORBIÆ (Pk.) B. and C.

On *Euphorbia corollata*, Steuben, 1892 (Martin Canse); Tippecanoe, 9, 1888 (Bolley).

MICROSPHERA GROSSULARIÆ (Wallr.) Lev.

On *Sambucus Canadensis*, Johnson, 9, 1890 (Fisher); Montgomery, 10, 1893.

MICROSPHÆRA QUERCINA (Schw.) Burrill.

On *Quercus alba*, Putnam, 10, 1891.

On *Quercus bicolor*, Johnson, 9, 1890 (Fisher); Vigo, 10, 1893.

On *Quercus lyrata*, Johnson, 9, 1890 (Fisher).

On *Quercus macrocarpa*, Johnson, 9, 1890 (Fisher).

On *Quercus Muhlenbergii*, Johnson, 9, 1890 (Fisher); Putnam, 10, 1893.

On *Quercus rubra*, Johnson, 9, 1890 (Fisher); Marshall, 10, 1893; Putnam, 10, 1893; Vigo, 10, 1893.

On *Quercus* sp., Montgomery (Brannon).

MICROSPHÆRA RAVENELII Berk.

On *Gleditschia triacanthos*, Johnson, 8, 1890 (Fisher); Vigo, 10, 1893; Montgomery (Brannon); Putnam, 10, 1893; Owen, 10, 1893.

MICROSPHÆRA RUSSELLII Clinton.

On *Oxalis stricta*, Johnson, 7, 1890 (Fisher); Putnam, 10, 1891; Montgomery, 10, 1893; 1893 (Olive).

MICROSPHÆRA SEMITOSTA B. and C.

On *Cephalanthus occidentalis*, Johnson, 9, 1890 (Fisher); Vigo, 10, 1893.

MICROSPHÆRA SYMPHORICARPI Howe.

On *Symphoricarpus vulgaris*, Putnam, 10, 1891; 11, 1892; 10, 1893.

MICROSPHÆRA VACCINII (Schw.) C. and P.

On *Vaccinium* sp., Marshall, 10, 1893.

PHYLLACTINIA SUFFULTA (Reb.) Sacc.

On *Carpinus Caroliniana*, Putnam, 10, 1891; Montgomery, 10, 1890 (Fisher).

On *Celastrus scandens*, Montgomery, 10, 1890 (Fisher).

On *Cornus florida*, Putnam, 10, 1891; 10, 1892.

On *Corylus Americana*, Montgomery, 10, 1890 (Fisher); Marshall, 10, 1893.

On *Fraxinus Americana*, Johnson, 9, 1890 (Fisher); Montgomery, 10, 1893; 1893 (Olive); Putnam, 10, 1893.

On *Fraxinus pubescens*, Johnson, 9, 1890 (Fisher).

On *Fraxinus quadrangulata*, Johnson, 10, 1890 (Fisher).

On *Fraxinus sambucifolia*, Johnson, 10, 1890 (Fisher).

On *Liriodendron tulipifera*, Johnson, 9, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Ostrya Virginica*, Montgomery, 10, 1890 (Fisher); Putnam, 10, 1891; 10, 1893.

On *Quercus coccinea*, Johnson, 9, 1890 (Fisher); Montgomery, 10, 1890 (Fisher).

On *Quercus palustris*, Shelby, 11, 1890 (Fisher); Vigo, 10, 1893.

On *Quercus rubra*, Vigo, 10, 1893.

On *Catalpa bignoniodes*, Montgomery, 1893 (Olive).

On *Xanthoxylum Americana*, Montgomery, 1893 (Olive).

PODOSPHERA BIUNCINATA C. & P.

On *Hamamelis Virginiana*, Putnam, 9, 1893; 10, 1893.

PODOSPHERA OXYACANTHE (D C.) DeBary.

On *Cratægus crus-galli*, Johnson, 7, 1890 (Fisher).

On *Cratægus spathulata*, Johnson, 7, 1890 (Fisher).

On *Cratægus tomentosa*, Johnson, 7, 1890 (Fisher).

On *Cydonia vulgaris*, Johnson, 8, 1890 (Fisher).

On *Prunus Americana*, Johnson, 10, 1890 (Fisher).

On *Prunus cerasus*, Johnson, 7, 1890 (Fisher); Putnam, 10, 1891; 7, 1893; Tippecanoe, 8, 1890 (Bolley).

On *Spiræa tomentosa*, Marshall, 10, 1893.

On *Cratægus* sp., Owen, 10, 1893.

SPILEROTHECA CASTAGNEI Lev.

On *Bidens chrysanthemoides*, Johnson, 9, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Bidens connata*, Johnson, 8, 1890 (Fisher); Montgomery, 10, 1893.

On *Bidens frondosa*, Johnson, 7, 1890 (Fisher); Putnam, 10, 1891; 7, 1893; Montgomery, 10, 1893.

On *Brunella vulgaris*, Johnson, 9, 1890 (Fisher); Marshall, 10, 1893.

On *Coreopsis trichosperma*, Johnson, 9, 1890 (Fisher).

On *Erechtites hieracifolia*, Johnson, 8, 1890 (Fisher); Marshall, 10, 1893; Montgomery, 1893 (Olive).

On *Erigeron Canadense*, Johnson, 10, 1890 (Fisher).

On *Erigeron* (Sp.), Montgomery (Brannon).

On *Pedicularis lanceolata*, Johnson, 8, 1890; 11, 1890 (Fisher).

On *Taraxacum officinale*, Montgomery (Brannon, Olive); Putnam, 10, 1891; Tippecanoe, 6, 1890 (Bolley).

SPILEROTHECA HUMULI (D C.) Burrill.

On *Agrimonia Eupatoria*, Montgomery, 10, 1890 (Fisher); Putnam, 11, 1891; 10, 1893; Marshall, 10, 1893.

On *Potentilla palustris*, Marshall, 10, 1893.

SPILEROTHECA MORS-UVÆ (Schw.) B. & C.

On *Ribes cynosbati*, Montgomery, 6, 1893 (Hughart).

SPILEROTHECA PANNOSA (Wallr.)

On *Geum album*, Johnson, 8, 1890 (Fisher).

On *Rosa lucida*, Johnson, 8, 1890 (Fisher).

On *Rosa* (sp. cult.) Putnam, 9, 1893.

SPILEROTHECA PHYTOPTOPHILA Kell. & Swingle.

On *Phytoptus* fascicles of *Celtis occidentalis*, Putnam, 5, 1890 (Arthur); 10, 1891; 11, 1893; Montgomery, 1893 (Olive); Tippecanoe, 12, 1893 (Arthur).

UNCINULA CIRCINATA C. & P.

On *Acer dasycarpum*, Montgomery (Brannon); Marshall, 10, 1893.

On *Acer rubrum*, Johnson, 1890 (Fisher).

On *Acer saccharum*, Johnson, 9, 1890 (Fisher); Putnam, 10, 1893; Montgomery, 1893 (Olive).

UNCINULA CLINTONII Pk.

On *Tilia Americana*, Montgomery, 10, 1890 (Fisher); Putnam, 10, 1893.

UNCINULA FLEXUOSA Pk.

On *Aesculus glabra*, Johnson, 7, 1890 (Fisher); Montgomery (Brannon, Olive).

On *Aesculus Hippocastanum*, Putnam, 10, 1893.

UNCINULA GENICULTA Gerard.

On *Morus rubra*, Johnson, 9, 1890 (Fisher); Montgomery, 10, 1890 (Fisher); 10, 1893.

UNCINULA MACROSPORA Pk.

On *Ulmus Americana*, Putnam, 10, 1891; 10, 1892; Owen, 10, 1893; Montgomery, 1893 (Olive); Wabash, 10, 1891 (Miller).

On *Ulmus fulva*, Johnson, 8, 1890 (Fisher); Montgomery, 1893 (Olive).

UNCINULA NECATOR (Schw.) Burrill.

On *Ampelopsis quinquefolia*, Johnson, 9, 1890 (Fisher); Montgomery (Brannon, Olive); Putnam, 10, 1891.

On *Vitis cordifolia*, Johnson, 9, 1890 (Fisher).

On *Vitis* (cult. sp.) Johnson, 9, 1890 (Fisher); Montgomery (Brannon, Olive); Putnam, 10, 1891; 10, 1893.

UNCINULA PARVULA C. & P.

On *Celtis occidentalis*, Johnson, 9, 1890 (Fisher); Marion, 1890 (Tracy); Putnam, 10, 1893.

UNCINULA SALICIS (D C.) Wint.

On *Salix nigra*, Johnson, 8, 1890 (Fisher).

On *Salix sericea*, Montgomery, 10, 1890 (Fisher).

On *Salix cordata*, Montgomery, 1893 (Olive).

On *Salix* sp. Montgomery (Brannon); Putnam, 9, 1891; Marshall, 10, 1893.

On *Populus tremuloides*, Marshall, 10, 1893.

HYPOCREACEÆ.

CLAVICEPS PURPUREA (Fr.) Tul.

Sclerotia on Rye, Putnam, 7, 1893; Tippecanoe (Arthur).

Sclerotia on *Elymus Virginicus*, Montgomery, 10, 1893.

CORDYCEPS OPHIOGLOSOIDES (Ehrh.) Sacc., Putnam, 11, 1891.

EPICHLØE TYPHINA (Pers.) Tul.

On *Festuca nutans*, Tippecanoe, 7, 1890 (Arthur).

On grass (sp. ig.), Vigo, 5, 1893; Putnam, 6, 1894.

HYPOCREA CITRINA (Pers.) Fr., Putnam, 11, 1891; 10, 1893.

HYPOCREA GELATINOSA (Tode.) Fr., Putnam, 10, 1891.

HYPOCREA RUFÆ (Pers.) Fr. (*Trichoderma viride*.)

Conidial stage, Putnam, 11, 1893.

SPILERIACEÆ.

DALDINIA CONCENTRICA (Bolt.) Ces. and DeNot.

On *Acer* sp., Putnam, 10, 1891.

DIATRYPE ALBOPRUIOSA (Schw.) Cooke. Vigo, 10, 1893.

DIATRYPE VIRESCENS (Schw.) E. and E. Putnam, 9, 1893.

DICHLENA FAGINEA (Pers.) Fr.

On *Fagus ferruginea*, Tippecanoe, 4, 1892 (Arthur); Putnam, 4, 1893.

EUTYPA SPINOSA (Pers.) Tul. Putnam, 11, 1892; 10, 1893.

GNOMONIA ULMEA (Schw.) Thüm.

On *Ulmus fulva*, Montgomery, 10, 1890 (Fisher); Johnson, 9, 1890 (Fisher). [Herb. U. S.]

HYPOXYLON ANNULATUM (Schw.) Mont. Putnam, 4, 1893.

HYPOXYLON ATROPUNCTATUM (Schw.) Cooke. Putnam, 4, 1893.

HYPOXYLON COCCINEUM Bull. Putnam, 12, 1891; 10, 1891.

HYPOXYLON COILERENS (Pers.) Fr.

On *Fagus ferruginea*, Putnam, 10, 1891.

HYPOXYLON MARGINATUM (Schw.) Berk., Putnam, 5, 1893.

HYPOXYLON PERFORATUM (Schw.) Sacc., Putnam, 10, 1891; 2, 1893.

HYPOXYLON RUBIGINOSUM (Pers.) Fr., Putnam, 10, 1891; 5, 1893.

LESTADIA BIDWELLII (Ell.) Viala et Rav.

On *Vitis cordifolia*, Johnson, 8, 1890 (Fisher); Putnam, 10, 1891.

On *Vitis* (cult.), Putnam, 7, 1893.

On *Ampelopsis quinquefolia*, Owen, 10, 1893.

MELANOMMA SPORADICUM E. & E., Putnam, 4, 1893.

NUMMULARIA BULLIARDI Tul., Putnam, 10, 1891.

OTTHIA MORBOSA (Schw.) E. & E.

. On *Prunus* sp., Floyd, 6, 1890 (Arthur); Putnam, 4, 1894.

ROSELLINIA AQUILA (Fr.) DeNot, Putnam, 10, 1891.

SCORIAS SPONGIOSA (Schw.) Fr.

On honey-dew dropped by *Aphidæ* on and under beech twigs. Putnam, 10, 1891; 4, 1893; Owen, 5, 1893.

SPHERELLA FRAGARIE Tul. (*Ramularia fragariae*).

Conidia on *Fragaria vesca*, Putnam, 5, 1892.

Conidia on *Fragaria elatior*, Johnson, 8, 1890 (Fisher).

SPHERELLA FRAXINICOLA (Schw.) Cooke.

On *Fraxinus Americana*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]

SPHERIA IRIDIS Schw.

On *Iris versicolor*, Montgomery, 1893 (Olive). [Herb. Wabash Coll.]

TRYBLIDIUM MINOR Cooke.

On *Salix* sp., Putnam, 5, 1892.

USTULINA VULGARIS Tul.

On *Quercus* sp., Montgomery, 4, 1892; Putnam, 10, 1891; 5, 1893.

VALSARIA EXASPERANS (Ger.) E. and E. Putnam, 12, 1891.

VALSARIA QUADRATA (Schw.) Sacc. (*Diatrype obesa* B. and C.)

On *Fagus ferruginea*, Putnam, 10, 1891.

XYLARIA POLYMORPHA (Pers.) Grev. Putnam, 11, 1891; Tippecanoe, 1892 (Arthur).

XYLARIA CORNIFORMIS Fr. Putnam, 10, 1891; 10, 1892; 10, 1893.

XYLARIA HYPOXYLON (L.) Grev. Putnam, 11, 1893.

DOTHIDEACEÆ.

PHYLLIOCHORA LESPEDEZE (Schw.) Cooke.

On *Lespedeza* sp., Marshall, 10, 1893.

DOTHIDIELLA ULMI (Duv.) Wint.

On *Ulmus Americana*, Montgomery, 1893 (Olive). [Herb. Wabash Coll.]

PHYLLIOCHORA GRAMINIS (Pers.) Fckl.

On *Panicum latifolium*, Tippecanoe, 9, 1888 (Bolley); Putnam, 10, 1892.

On *Muhlenbergia* sp., Putnam, 10, 1892.

On *Asprella hystrix*, Montgomery, 10, 1893.

On *Muhlenbergia Mexicana*, Johnson, 11, 1890 (Fisher).

On *Elymus Canadensis*, Montgomery, 11, 1890 (Fisher).

On *Elymus* sp., Putnam, 10, 1892.

PHYLLACHORA TRIFOLII (Pers.) Fckl.

On *Trifolium pratense*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]

FUNGI IMPERFECTI.

SPHÆROPSIDEÆ.

ACTINONEMA ROSÆ Fr. (*Asteroma rosæ* Lib.).

On *Rosa* sp. in greenhouse, Tippecanoe, 1, 1887 (Barnes); 10, 1892 (Arthur).

CINCINNOBOLUS CESATHI DeBary.

On Mycelium of *Erysiphei* on *Helianthus* sp., Tippecanoe, 1888 (Bolley).

On Mycelium of *Erysiphei* on *Taraxacum officinale* and *Solidago Canadensis*, Johnson, 7, 1890 (Fisher).

On Mycelium of *Erysiphei* on *Solidago arguta*, *S. latifolia*, *Aster Shortii*, *Rudbeckia triloba*, *Hydrophyllum Virginicum*, Montgomery, 10, 1890 (Fisher).

On *Sphærotheca Castagnei* on *Taraxacum*, Montgomery, 1893 (Olive).

On *Phyllactinia suffulta* on *Liriodendron*, Montgomery, 1893 (Olive).

On *Erysiphe* sp. on *Erigeron*, Montgomery, 1893 (Olive).

DARLUCA FILUM (Riv.) Cast.

On *Uredo* on *Carex* sp., Johnson, 7, 1890 (Fisher). [Herb. U. S.]

LEPTOSTROMA HYPOPHYLLUM B. & Rav.

On *Gleditschia triacanthos*, Marion, 8, 1890 (Arthur); Tippecanoe, 9, 1892 (Arthur); Putnam, 9, 1893.

MELASMIA ? GALII E. & E.

On *Galium trifidum latifolium*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]

PHLEOSPORA ACERIS (Lib.) Sacc.

On *Acer rubrum*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]

PHLEOSPORA ULMI (Fr.) Wallr.

On *Ulmus fulva*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

PHYLLOSTICTA ASIMINÆ E. & K.

On *Asimina triloba*, Johnson, 8, 1890 (Fisher); Putnam, 7, 1893.

PHYLLOSTICTA CELTIDIS E. & K.

On *Celtis occidentalis*, Montgomery, 10, 1890 (Fisher). [Herb. U. S.]

PHYLLOSTICTA COMMONSII E. & E.

On *Paeonia* (cult.), Montgomery, 1893 (Olive). [Herb. Wabash Coll.]

PHYLLOSTICTA CRUENTA Kickx.

On *Smilacina racemosa*, Montgomery, 1893 (Olive).

PHYLLOSTICTA PAVIE Desm. (*P. sphæropsoidea* E. & E.)

On *Aesculus glabra*, Montgomery, 7, 1890 (Fisher); 1893 (Olive); Johnson, 8, 1890 (Fisher); Brown, 5, 1893.

PHYLLOSTICTA QUERCUS Sacc & Speg.

On *Quercus macrocarpa* Montgomery, 1893 (Olive). [Herb. Wabash Coll]

PHYLLOSTICTA SANGUINARIE Wint.

On *Sanguinaria Canadensis*, Brown, 5, 1893, immature.

PHYLLOSTICTA SASSAFRAS Cooke.

On *Sassafras*, Montgomery, 7, 1890 (Fisher). [Herb. U. S.]

SEPTORIA ASCLEPIADICOLA E. & E.

On *Asclepias incarnata*, Johnson, 10, 1890 (Fisher). [Herb. U. S.]

SEPTORIA CACALIE E. & K.

On *Cacalia atriplicifolia*, Owen, 10, 1893; Montgomery, 1893 (Olive).

SEPTORIA CANNABINA West. ?

On *Cannabis sativa*, Montgomery, 7, 1890 (Fisher). [Herb. U. S.]

SEPTORIA CONSPICUA E. & M.

On *Steironema ciliatum*, Johnson, 7, 1890; 10, 1890 (Fisher). [Herb. U. S.]

SEPTORIA CRATEGI Kickx.

On *Crataegus* sp., Owen, 10, 1893.

SEPTORIA DENTARIE Pk.

On *Dentaria laciniata*, Montgomery, 1893 (Olive).

SEPTORIA FLAGELLARIS E. and E.

On *Convolvulus sepium*, Monroe, 5, 1893.

SEPTORIA HELIANTHI E. and K.

On *Heliopsis laevis*, Montgomery, 7, 1890 (Fisher).

On *Helianthus annuus*, Montgomery, 1893 (Olive).

SEPTORIA LACTUCE Pass.

On *Lactuca sativa*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

SEPTORIA LAPPARUM Sacc.

On *Arctium lappa*, Montgomery, 1893 (Olive).

SEPTORIA LEUCOSTOMA E. and E.

On *Fraxinus Americana*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

SEPTORIA MICROSPORA E. and E.

On *Asprella hystrix*, Montgomery, 7, 1890 (Fisher). [Herb. U. S.]

SEPTORIA OENOTHERAE B. and C.

On *Oenothera biennis*, Vigo, 5, 1893.

SEPTORIA PODOPHYLLINA Pk.

On *Podophyllum peltatum*, Monroe, 5, 1893; Putnam, 5, 1893 (Melia Ellis); Montgomery, 1893 (Olive).

SEPTORIA POLYGONORUM Desm.

On *Polygonum* sp., Putnam, 9, 1893; 10, 1893.

SEPTORIA PSILOSTEGA E. & M.

On *Galium circaezans*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]

SEPTORIA RUBI Westd.

On *Rubus* (blackberry), Vigo, 5, 1893.

On *Rubus villosus*, Montgomery, 1893 (Olive).

SEPTORIA SISYMBRII Ell.

On *Dentaria laciniata*, Vigo, 5, 1893.

SEPTORIA TRILLII Pk.

On *Trillium grandiflorum*, Montgomery, 1893 (Olive).

On *Trillium sessile*, Montgomery, 1893 (Olive).

On *Trillium recurvatum*, Montgomery, 1893 (Olive).

SEPTORIA VIOLE Westd.

On *Viola palmata cucullata*, 1893 (Olive).

SEPTORIA sp.

On *Cicuta maculata*, Johnson, 11, 1890 (Fisher). ["Not S. Sii." Herb. U. S.]

SPILEROGRAPHIUM FRAXINI Pk. Putnam, 4, 1892.

STAGNOSPORA COLLAPSA (C. & E.) Sacc.

On *Acer dasycarpum*, Putnam, 3, 1893.

VERMICULARIA HERBARUM Westd. (*V. dianthi* Westd.)

On carnations in greenhouse, Tippecanoe, 3, 1889 (Arthur).

HYPHOMYCETES.

CERATOPHORUM UNCINATUM (Cl. and Pk.) Sacc.

On *Quercus macrocarpa*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA AMPELOPSIDIS Pk.

On *Ampelopsis quinquefolia*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA APII Fres.

On *Pastinaca sativa*, Putnam, 9, 1893.

CERCOSPORA CERCIDICOLA Ell.

On *Cercis Canadensis*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA CHIONEAE E. and E.

On *Cercis Canadensis*, Montgomery, 1893 (Olive).

CERCOSPORA DIANTHERAE E. and K.

On *Dianthera Americana*, Montgomery, 1893 (Olive).

CERCOSPORA DUBIA (Russ.) Wint.

(On *Chenopodium album*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA ECHINOCYSTIS E. and M.

(On *Echinocystis lobata*, Montgomery, 1893 (Olive).

CERCOSPORA EFFUSA (B. and C.) E. and E.

(On *Lobelia syphilitica*, Putnam, 10, 1892; 9, 1893.

CERCOSPORA ELONGATA Pk.

(On *Dipsacus sylvestris*, Montgomery, 1893 (Olive).

CERCOSPORA EUPATORII Pk.

(On *Eupatorium perfoliatum*, Montgomery, 1893 (Olive).

CERCOSPORA FLAGELLARIS E. & M.

(On *Phytolacca decandra*, Montgomery, 1893 (Olive).

CERCOSPORA GRANULIFORMIS Ell. & Hol.

(On *Viola palmata cucullata*, Montgomery 7, 1890; 10, 1890 (Fisher).
[Herb. U. S.]

CERCOSPORA HYDROPIPERIS (Thüm.) Speg.

(On *Polygonum hydropiper*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA LIPPIE E. & E.

(On *Lippia lanceolata*, Montgomery, 1893 (Olive).

CERCOSPORA OCLATA E. & K.

(On *Vernonia noveboracensis*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA PENSTEMONIS E. & K.

(On *Penstemon levigatus digitalis*, Montgomery, 1893 (Olive).

CERCOSPORA PRENANTHIS, E. & K.

(On *Prenanthes alba*, Montgomery, 1893 (Olive).

CERCOSPORA PTELEAE Wint.

(On *Ptelea trifoliata*, Johnson, 11, 1890 (Fisher); Montgomery, 1893 (Olive).
[Herb. U. S. and Wabash Coll.]

CERCOSPORA RHUINA C. & E.

(On *Rhus glabra*, Montgomery, 7, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA ROSICOLA Pass.

(On *Rosa setigera*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA SAURURI C. & E.

(On *Saururus*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

CERCOSPORA SEDOIDES E. & E.

(On *Penthorum sedoides*, Johnson, 8, 1890; 10, 1890 (Fisher). [Herb.
U. S.]

CERCOSPORA SIMULATA E. & E.

- (On *Cassia Marilandica*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]
- CERCOSPORA XANTHOXYLI** Cke.
- (On *Xanthoxylum Americanum*, Montgomery, 1893 (Olive).
- CERCOSPORELLA CANA** Sacc.
- (On *Erigeron annuus*, Johnson, 7, 1890; 10, 1890 (Fisher). [Herb. U. S.]
- CERCOSPORELLA CLAVATA** (Ger.) Pk.
- (On *Asclepias incarnata*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]
- CERCOSPORELLA RACEMOSA** E. & M.
- (On *Teucrium Canadense*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]
- CERCOSPORELLA TEUCRII** E. & K.
- (On *Teucrium Canadense*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]
- DIDYMARIA UNGERI** Cda.
- (On *Ranunculus septentrionalis*, Johnson, 10, 1890 (Fisher). [Herb. U. S.]
- FUSARIUM MINIATUM** (B. & C.) Sacc.
- (On trunk of *Ostrya* injured by woodpeckers, Putnam, 5, 1892.
- (On old wood, Putnam, 5, 1893.
- FUSARIUM RIMOSUM** (Pk.) Sacc.
- (On cut ends of corn stalks. Putnam, 10, 1893.
- FUSICLADIUM DENDRITICUM** (Wallr.) Fckl.
- (On *Pirus malus*, Johnson, 7, 1890 (Fisher). [Herb. U. S.]
- HETEROSPORIUM GRACILE** (Wallr.) Sacc.
- (On *Iris versicolor*, Montgomery, 1893 (Olive). [Herb. Wabash Coll.]
- MONILIA AUREO-FULVA** (Link) Gmel.
- (On decaying wood, Putnam, 10, 1893.
- OIDIUM LACTIS** Fres.
- (On surface of milk, Tippecanoe, 3, 1891 (Arthur). [Herb. Arthur.]
- OOSPORA SCABIES** Thax.
- (On potatoes producing deep scab, Tippecanoe, 2, 1892 (Arthur).
- (On sugar beet producing scab, Tippecanoe, 3, 1891 (Arthur).
- POLYTHRINCUM TRIFOLII** Kze.
- (On *Trifolium repens*, Putnam, 6, 1893; Johnson, 11, 1890 (Fisher).
- RAMULARIA ARMORACEÆ** Fckl.
- (On *Nasturtium armoracia*, Montgomery, 1893 (Olive).
- RAMULARIA PLANTAGINIS** E. & M.
- (On *Plantago major*, Johnson, 8, 1890; 10, 1890 (Fisher). [Herb. U. S.]
- RAMULARIA RUFO-MACULATA** Pk.
- (On *Polygonum acre*, Johnson, 1890 (Fisher). [Herb. U. S.]
- RHINOTRICHUM CURTISII** Berk., Putnam, 10, 1891.

SCOLECOTRICHUM GRAMINIS Fekl.

On *Phleum pratense*, Johnson, 11, 1890 (Fisher).

On *Poa nemoralis*, Johnson, 11, 1890 (Fisher).

On *Poa pratensis*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]

STREPTOTHRIX ATRA B. & C., Tippecanoe, 10, 1888 (Bolley); Putnam, 11, 1891.

MELANCONIEÆ.**CYLINDROSPORIUM IRIDIS Ell. and Hals.**

On *Iris versicolor*, Montgomery, 1893 (Olive).

GLEOSPORIUM APOCYNi Pk.

On *Apocynum cannabinum*, Johnson, 8, 1890 (Fisher). [Herb. U. S.]

GLEOSPORIUM LINDEMUTHIANUM Sacc. and Magn.

On cultivated beans, Tippecanoe, 5, 1890 (Arthur); Putnam, 9, 1893.

GLEOSPORIUM SEPTORIODES Sacc.

On *Quercus* sp., Montgomery, 7, 1890 (Fisher). [Herb. U. S.]

MARSONIA MARTINI Sacc. and Ell.

On *Quercus alba*, Montgomery, 10, 1890 (Fisher).

On *Quercus rubra*, Montgomery, 10, 1890 (Fisher).

On *Quercus Muhlenbergii*, Montgomery, 10, 1890 (Fisher).

On *Quercus bicolor*, Montgomery, 10, 1890 (Fisher). [Herb. U. S.]

MYXOSPORIUM NITIDUM B. and C.

On *Cornus*, Tippecanoe, 4, 1892 (Arthur).

BASIDIOMYCETES.**USTILAGINEÆ.****ENTYLOMA COMPOSITARUM Farl.**

On *Ambrosia artemisiæfolia*, Tippecanoe, 7, 1889 (Arthur).

ENTYLOMA PHYSALIDIS (K. and C.) Wint.

On *Physalis pubescens*, Johnson, 11, 1890 (Fisher); Putnam, 9, 1893.

On *Physalis Philadelphica*, Johnson, 11, 1890 (Fisher).

TILLETIA STRIEFORMIS (Westend.) Wint.

On *Phleum pratense*, Putnam, 5, 1892; 5, 1893; Tippecanoe, 5, 1889 (Bolley).

UROCYSTIS ANEMONES (Pers.) Wint.

On *Hepatica acutiloba*, Tippecanoe, 5, 1893 (Arthur).

USTILAGO ANOMALA J. Kunze.

On *Polygonum dumetorum scandens*, Putnam, 9, 1893.

USTILAGO AVENÆ (Pers.) Jensen.

On *Avena sativa*, Montgomery, 1893 (Olive); Tippecanoe, 1891 (Arthur).

USTILAGO HORDEI.

On Barley, Dearborn 6, 1888 (Bolley). [Herb. Arthur.]

USTILAGO PANICI-GLAUCI [Wallr.] Wint. (*U. neglecta* Niessl.)

On *Setaria glauca*, Montgomery, 1893 (Olive).

USTILAGO RABENHORSTIANA Kuhn.

On *Panicum capillare*, Putnam 10, 1892.

USTILAGO SYNTHESMÆ (Schw.) Pk.

On *Cenchrus tribuloides*, Putnam, 10, 1892.

USTILAGO TRITICI (Pers.) Jensen.

On *Triticum vulgare*, Brown, 5, 1893; Putnam, 6, 1893; Montgomery, 1893 (Olive); Wabash, 6, 1888 (Miller); Tippecanoe, 1893 (Arthur).

USTILAGO UTRICULOSA (Nees) Wint.

On *Polygonum amphibium*, Wabash, 10, 1890 (Miller).

USTILAGO ZEE-MAYS (D C.) Wint.

On *Zea mays*, Putnam, 9, 1892; 9, 1893; Johnson, 10, 1890 (Fisher).

UREDINEÆ.**ÆCIDIUM AQUILEGIE** Pers.

On *Aquilegia* sp., Tippecanoe, 6, 1889 (Bolley).

ÆCIDIUM ASTERUM Schw.

On *Aster cordifolius*, Montgomery, 1893 (Olive).

On *Aster sagittifolius*, Montgomery, 1893 (Olive).

On *Aster* sp., Vigo, 5, 1893; Tippecanoe, 5, 1893 (Arthur).

On *Solidago latifolia*, Putnam, 7, 1893.

On *Solidago Canadensis*, Laporte, 6, 1893 (Arthur).

On *Solidago cæsia*, Montgomery, 1893 (Olive).

On *Solidago* sp., Vigo, 5, 1893.

ÆCIDIUM BERBERIDIS Pers.

On *Berberis vulgaris*, Lagrange, 7, 1889 (Arthur). [Herb. Arthur.]

ÆCIDIUM DICENTRÆ Trelease.

On *Dicentra cucullaria*, Montgomery, 1893 (Olive).

ÆCIDIUM EUPHORBIE Gmel.

On *Euphorbia corollata*, Johnson, 7, 1890 (Fisher).

On *Euphorbia dentata*, Putnam, 9, 1891.

On *Euphorbia Preslii*, Johnson, 7, 1890 (Fisher); Fulton, 10, 1893.

On *Euphorbia maculata*? Montgomery (Rose).

On *Euphorbia* sp., Putnam, 10, 1892; Tippecanoe 7, 1890 (Bolley).

ÆCIDIUM GERANII D C.

On *Geranium maculatum*, Vigo, 5, 1893.

ÆCIDIUM GROSSULARIÆ D C.

On *Ribes rotundifolium*, Putnam, 5, 1893.

On *Ribes cynosbati*, Putnam, 5, 1892; Montgomery, 1893 (Olive).

ÆCIDIUM HEPATICATUM Schw.

On *Hepatica acutiloba*, Montgomery, 4, 1892; 5, 1893 (Thomas).

ÆCIDIUM HYDNOIDEUM B. & C.

On *Dirca palustris*, Johnson, 7, 1890 (Fisher); Montgomery, 1893 (Olive)
Wabash, 7, 1887 (Miller).

ÆCIDIUM IMPATIENTIS Schw.

On *Impatiens fulva*, Johnson, 7, 1890 (Fisher); Putnam, 7, 1893; Montgomery (Rose).

ÆCIDIUM LYCOPI Gerard.

On *Lycopus* sp., Vigo, 5, 1893.

ÆCIDIUM MARIE-WILSONI Peck.

On *Viola palmata cucullata*, Putnam, 5, 1893.

ÆCIDIUM OENOTHERÆ Pk.

On *Oenothera biennis*, Vigo, 5, 1893.

ÆCIDIUM ONOBRYCHIDIS Burrill.

On *Psoralea Onobrychis*, Vigo, 5, 1893.

ÆCIDIUM PTELEÆ B. & C.

On *Ptelea trifoliata*, Montgomery, 1893 (Olive).

ÆCIDIUM PUSTULATUM Curt.

On *Comandra umbellata*, Vigo, 5, 1893; Montgomery, 1893 (Olive).

ÆCIDIUM RANUNCULI Schw.

On *Ranunculus abortivus*, Decatur, 5, 1889 (Arthur); Putnam, 4, 1892;
5, 1893; Brown, 5, 1893.

ÆCIDIUM SAMBUCI Schw.

On *Sambucus Canadensis*, Johnson, 7, 1890 (Fisher); Putnam, 5, 1892;
5, 1893; Brown, 5, 1893; Vigo, 5, 1893; Montgomery, 1893 (Olive).

CEOMA AGRIMONIÆ Schw.

On *Agrimonia eupatoria*, Johnson, 7, 1890 (Fisher); Putnam, 9, 1891;
Owen, 10, 1893; Montgomery (Rose).

On *Agrimonia parviflora*, Putnam, 9, 1893; Marshall, 10, 1893.

COLEOSPORIUM RUBI Ell. and Hals.

On *Rubus cuneifolius*, Johnson, 9, 1890 (Fisher).

On *Rubus villosus*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]

COLEOSPORIUM SONCHI-ARVENSIS (Pers.) Lev.

On *Aster cordifolius*, Montgomery, 10, 1890 (Fisher).

- On *Aster azureus*, Montgomery, 10, 1890 (Fisher); 1893 (Olive).
 On *Aster Novæ-angliæ*, Montgomery, Johnson, 8, 1890 (Fisher); Montgomery, 10, 1890 (Fisher).
 On *Aster paniculatus*, Montgomery, 10, 1890 (Fisher).
 On *Aster puniceus*, Johnson, 10, 1890 (Fisher).
 On *Aster sagittæfolius*, Johnson, 8, 1890 (Fisher).
 On *Aster salicifolius*, Johnson, 11, 1890 (Fisher).
 On *Aster Shortii*, Montgomery, 10, 1890 (Fisher).
 On *Aster Tradescanti*, Johnson, 7, 1890 (Fisher).
 On *Solidago arguta*, Montgomery, 10, 1890 (Fisher).
 On *Solidago cæsia*, Montgomery, 7, 1890 (Fisher); Johnson, 11, 1890 (Fisher).
 On *Solidago Canadensis*, Johnson, 7, 1890 (Fisher); Montgomery, 10, 1890 (Fisher); Wabash, 10, 1890 (Miller).
 On *Solidago latifolia*, Montgomery, 10, 1890 (Fisher); 1893 (Olive); Owen, 10, 1893.
 On *Solidago patula*, Montgomery, 10, 1890 (Fisher).
 On *Solidago rugosa*, Johnson, 11, 1890 (Fisher).
 On *Solidago serotina*, Johnson, 10, 1890 (Fisher); Owen, 10, 1893.
 On *Vernonia fasciculata*, Putnam, 10, 1891; Montgomery, 1893 (Olive).
 On *Vernonia Noveboracensis*, Johnson, 8, 1890 (Fisher).
 On *Hieracium* sp., Vigo, 5, 1893.

GYMNOSPORANGIUM GLOBOSUM Farl.

- On *Juniperus Virginiana*, Putnam, 4, 1892; 5, 1893; Owen, 5, 1893.

GYMNOSPORANGIUM MACROPUS Link.

- On *Juniperus Virginiana*, Putnam 3, 1892; 4, 1892; 5, 1893; Owen, 5, 1893; Montgomery, 1893 (Olive); Tippecanoe, 3, 1889 (Bolley).

MELAMPSORA POPULINA (Jacq.) Lev.

- On *Populus balsamifera*, Montgomery, 10, 1890 (Fisher).
 On *Populus grandidentata*, Montgomery, 10, 1890 (Fisher); Putnam, 10, 1893.
 On *Populus monilifera*, Johnson, 7, 1890 (Fisher); Putnam, 9, 1891; 10, 1893; Montgomery, 1893 (Olive); Tippecanoe, 9, 1888 (Bolley).
 On *Populus tremuloides*, Marshall, 10, 1893.

MELAMPSORA SALICINA Lev.

- On *Salix cordata*, Montgomery, 1893 (Olive.)
 On *Salix nigra*, Johnson, 10, 1890 (Fisher).
 On *Salix discolor*, Montgomery, 10, 1890 (Fisher).

On *Salix longifolia*, Johnson, 10, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Salix* sp., Johnson 7, 1890 (Fisher); Putnam, 10, 1892; 10, 1893.

PHRAGMIDIUM FRAGARIAE (D C.) Rossm.

On *Potentilla Canadensis*, Johnson, 9, 1890 (Fisher); Marshall, 10, 1893;
Owen 10, 1893; Vigo, 10, 1893; 5, 1893 (Uredo); Tippecanoe, 9, 1889
(Bolley).

PHRAGMIDIUM SUBCORTICIUM (Schrank) Wint.

On *Rosa lucida*, Johnson, 9, 1890 (Fisher).

On *Rosa setigera*, Johnson, 7, 1890 (Fisher).

On *Rosa Carolina*, Putnam, 9, 1893.

On *Rosa* (sp. cult.), Putnam, 10, 1891; 11, 1892; 9, 1893; Dearborn, 9, 1888
(Bolley).

On *Rosa* (sp.) Vigo 5, 1893; Brown, 5, 1893 (Uredo).

PUCCINIA ANDROPOGI Schw.

On *Andropogon* sp., Vigo, 10, 1893.

PUCCINIA ANGUSTATA Pk.

On *Scirpus atrovirens*, Johnson, 11, 1890 (Fisher); Putnam, 9, 1891; Tip-
pecanoe, 9, 1889 (Bolley).

On *Eriophorum cyperinum*, Putnam, 10, 1891; Fulton, 10, 1893.

PUCCINIA APOCRYPTA Ell & Tracy.

On *Asprella hystrix*, Johnson 11, 1890 (Fisher). [Herb. U. S.]

PUCCINIA ARGENTATA (Schultz.) Wint.

II., On *Impatiens flava*, Johnson, 9, 1890, (Fisher). [Herb. U. S.]

PUCCINIA ASTERIS Duby. ;

On *Aster cordifolius*, Montgomery, 10, 1890 (Fisher).

On *Aster paniculatus*, Montgomery, 10, 1890 (Fisher).

On *Aster* sp., W. Lafayette, 10, 1889 (Bolley).

PUCCINIA BOLLEYANA DeToni.

On *Carex* sp., Tippecanoe, 11, 1888 (Bolley).

PUCCINIA CARICIS (Schum.) Reb.

On *Carex bullata*, Johnson, 9, 1890 (Fisher).

On *Carex fœnea*, Montgomery, 11, 1890 (Fisher).

On *Carex lurida*, Montgomery, 11, 1890 (Fisher).

On *Carex straminea*, Johnson, 11, 1890 (Fisher).

On *Carex virescens*, Montgomery, 11, 1890 (Fisher).

On *Carex* sp., Johnson 11, 1890 (Fisher); Putnam, 10, 1891; 10, 1893;
Fulton, 10, 1893; Montgomery, 1893 (Olive); Boone, 3, 1891 (Arthur).

On *Dulichium spathaceum*, Marshall, 10, 1893.

Puccinia circæe Pers.

On *Circæa Lutetiana*, Johnson, 7, 1890 (Fisher); Putnam, 10, 1893; Wabash 7, 1886 (Miller).

Puccinia convolvuli (Pers.) Cast.

On *Convolvulus sepium*, Putnam, 9, 1891; 9, 1893.

Puccinia coronata Corda.

On *Calamagrostis Canadensis*, Tippecanoe, 11, 1888 (Bolley).

Puccinia cyperi Arthur.

On *Cyperus* sp., Putnam, 10, 1893.

Puccinia davi Clinton.

On *Steironema ciliatum*, Johnson, 8, 1890 (Fisher); Putnam, 10, 1893.

Puccinia dochmia B. and C.

On *Muhlenbergia diffusa*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]

Puccinia eleocharidis Arthur.

On *Eleocharis palustris*, Tippecanoe, 11, 1888 (Bolley).

Puccinia emaculata Schw.

On *Panicum capillare*, Putnam, 10, 1892; 9, 1893; Montgomery, 1893 (Olive).

Puccinia flosculosorum (A. and S.) Roehl.

On *Cnicus lanceolatus*, 7, 1890;* 9, 1890† (Fisher); Marion, 8, 1890; (Bolley); Marshall, 10, 1893; Putnam, 9, 1893.

On *Taraxacum officinale*, Johnson, 8, 1890‡ (Fisher); Putnam, 5, 1893; Montgomery, 1893 (Olive); Tippecanoe, 9, 1888 (Bolley).

Puccinia galii (Pers.) Wint.

On *Galium asprellum*, Johnson, 11, 1890 (Fisher).

On *Galium concinnum*, Johnson, 7, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Galium triflorum*, Putnam, 11, 1891; 10, 1893; Montgomery, 10, 1893.

Puccinia graminis Pers.

On *Agrostis* sp., Putnam, 10, 1893.

II. On *Avena sativa*, Putnam, 7, 1893; (III.) Montgomery, 1893 (Olive); Tippecanoe, 10, 1888 (Bolley).

On *Poa pratensis*, Montgomery, 11, 1890 (Fisher); Marshall, 10, 1893; Putnam, 10, 1893.

On *Poa compressa*, Montgomery, 11, 1890 (Fisher).

*In Coll. U. S. as *P. cirsii-lanceolati*.

†In Coll. U. S. as *P. suaveolens*.

‡In Coll. U. S. as *P. hieracii*.

On *Triticum vulgare*, Johnson, 7, 1890 (Fisher); Putnam, 9, 1893; Tippecanoe, 6, 1890 (Arthur).

PUCCINIA HELIOPSISIDIS Schw.

On *Heliopsis scabra*, Johnson, 9, 1890 (Fisher). [Herb. U. S.]

PUCCINIA INDUSIATA Dietel & Holway *ined.*

On *Cyperus strigosus*, Putnam, 9, 1893; 10, 1893.

On *Cyperus* sp., Tippecanoe, 9, 1888 (Bolley).

PUCCINIA INTERSTITIALIS (Schl.) Tranzschel. (*Uredo*=*Cæoma nitens* Schw.)

II. On *Rubus* (blackberry), Putnam, 5, 1892; 5, 1893; Vigo, 5, 1893.

II. On *Rubus villosus*, Montgomery, 1893 (Olive).

II. On *Rubus occidentalis*, Montgomery, 1893 (Olive); Marshall, 5, 1889 (Parks in Herb. Arthur).

PUCCINIA KUHNIE Schw.

On *Kuhnia eupatorioides*, Tippecanoe, 9, 1888 (Bolley).

PUCCINIA LATERIPES B. & Rav.

On *Ruellia strepens*, Johnson, 7, 1890 (Fisher); Owen, 10, 1893; Wabash, 7, 1887 (Miller).

PUCCINIA LOBELIE Gerard.

On *Lobelia syphilitica*, Johnson, 7, 1890 (Fisher); Putnam, 10, 1892; 9, 1893; Fulton, 10, 1893; Tippecanoe, 9, 1883 (Arthur); Vermillion, 7, 1889 (Arthur).

PUCCINIA MAYDIS Carr.

On *Zea mays*, Putnam, 10, 1891; 9, 1893; Montgomery, 1893 (Olive); Dearborn, 8, 1889 (Bolley).

PUCCINIA MENTHÆ Pers.

On *Blephilia hirsuta*, Johnson, 9, 1890 (Fisher); Montgomery, 11, 1890 (Fisher).

On *Cunila Mariana*, Monroe, 9, 1886 (Blatchley).

On *Mentha Canadensis*, Johnson, 8, 1890 (Fisher); Marshall, 10, 1893; Tippecanoe, 9, 1893 (Arthur).

On *Monarda fistulosa*, Montgomery, 10, 1890 (Fisher); Marshall, 10, 1893; Vigo, 10, 1893.

On *Monarda?* sp., Owen, 10, 1893.

On *Pycnanthemum lanceolatum*, Marshall, 10, 1893.

On *Pycnanthemum muticum*, Vigo, 10, 1893.

PUCCINIA PODOPHYLLI Schw.

On *Podophyllum peltatum*, Johnson, 7, 1890 (Fisher); Monroe, 5, 1893; Brown, 5, 1893; Owen, 5, 1893; Vigo, 5, 1893; Putnam, 5, 1892; Mont-

gomery, 1893 (Olive); Wabash, 6, 1890 (Miller); Dearborn, 1889 (Bolley).

Puccinia polygoni-amphibii Pers.

On *Polygonum acre*, Johnson, 10, 1890 (Fisher); Putnam, 10, 1891: 10, 1893.

On *Polygonum Muhlenbergii*, Fulton, 10, 1893; Wabash, 5, 1890 (Miller).

Puccinia prenanthis (Pers.) Fckl.

I. III. On *Prenanthes* sp., Vigo, 5, 1893.

On *Prenanthes alba*, Putnam, 5, 1890 (Arthur).

Puccinia ranunculi Seymour.

On *Ranunculus repens*, Montgomery, 1893 (Olive).

Puccinia rubigo-vera (D C.) Wint.

On *Elymus Virginicus*, Tippecanoe, 10, 1888 (Bolley).

On *Avena sativa*, Johnson, 7, 1890 (Fisher).

On *Muhlenbergia diffusa*, 7, 1890 (Fisher).

Puccinia saniculae Grev.

On *Sanicula Canadensis*, Montgomery (Rose).

Puccinia schroeteriana Plowr. & Magnus

On *Carex stenolepis*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]

Puccinia silphii Schw.

On *Silphium* sp., Putnam, 10, 1891.

Puccinia tanacetii D C.

On *Helianthus annuus*, Johnson, 9, 1890 (Fisher); Putnam, 10, 1891; 11, 1892; Montgomery, 1893 (Olive).

On *Helianthus divaricatus*, Montgomery, 10, 1890 (Fisher).

On *Helianthus strumosus*, Johnson, 8, 1890 (Fisher); Tippecanoe, 9, 1888 (Bolley).

On *Helianthus tracheliiifolius*, Montgomery, 10, 1890 (Fisher); Shelby, 11, 1890 (Fisher).

On *Helianthus grosse-serratus*, Montgomery, 1893 (Olive).

On *Helianthus* sp., Putnam 10, 1893; Vigo, 10, 1893.

Puccinia tenuis Burrill.

On *Eupatorium ageratoides*, Putnam, 9, 1893.

Puccinia thalictri Chev.

II., III. On *Thalictrum dioicum*, Montgomery, 6, 1893 (Olive).

Puccinia vernoniae Schw.

On dead stems *Vernonia fasciculata*, Putnam, 12, 1892.

On *Vernonia fasciculata*, Putnam, 10, 1893.

PUCCINIA VIOLE (Schum.) D C.

On *Viola palmata cucullata*, Johnson, 8, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Viola striata*, Montgomery, 10, 1890 (Fisher); Owen, 10, 1893; Putnam, 10, 1893.

I. On *Viola* sp., Vigo, 5, 1893; Putnam, 5, 1893.

PUCCINIA VULPINOIDES Diet. & Holway ined.

On *Carex vulpinoides*, Tippecanoe, 11, 1888 (Bolley).

PUCCINIA XANTHII Schw.

On *Ambrosia trifida*, Dearborn, 8, 1890 (Bolley).

On *Xanthium Canadense*, Montgomery, 10, 1890 (Fisher); 10, 1893; Putnam, 9, 1893.

On *Xanthium strumarium*, Johnson, 7, 1890 (Fisher); Putnam, 9, 1891; 7, 1893; Montgomery, 1893 (Olive); Tippecanoe, 8, 1890 (Arthur).

ROESTELIA LACERATA (Sow.) Fr.

On *Crataegus coccinea*, Montgomery, 1893 (Olive).

On *Crataegus punctata*, Montgomery, 1893 (Olive); Putnam, 9, 1893.

ROESTELIA PYRATA THAX.

On *Pyrus communis*, Wabash, 9, 1887 (Miller).

On *Pyrus coronaria*, Wabash, 8, 1891 (Miller).

URED O HYDRANGÆ B. & C.

On *Hydrangea arborescens*, Marion, 8, 1890 (Tracy); Montgomery, 8, 1890, 10, 1890 (Fisher); Putnam; 10, 1891.

URED O POLYPODII (Pers.) D C.

On *Cystopteris fragilis*, Putnam, 7, 1893.

UROMYCES APPENDICULATA (Pers.) Lev.

On *Phaseolus* (sp.) Montgomery, 10, 1890 (Fisher); 1893 (Olive); Putnam, 10, 1892; 7, 1893.

On *Strophostyles angulosa*, Montgomery, 1893 (Olive.)

UROMYCES CALADII (Schw.) Farl.

I. On *Arisæma dracontium*, Vigo, 5, 1893; Brown 5, 1893; (III) Montgomery 1893 (Olive).

I. On *Arisæma triphyllum*, Putnam, 5, 1892; Monroe, 5, 1893; Owen, 5, 1893; Vigo, 5, 1893.

III. On *Arisæma triphyllum*, Johnson, 7, 1890 (Fisher); Putnam, 7, 1893; Montgomery 1893 (Olive).

UROMYCES CARYOPHYLLINUS (Schr.) Schröt.

On *Carnations*, Marion, 1892 (Arthur).

UROMYCES DACTYLOIDES Otth.

II. On *Poa pratensis*, Johnson, 11, 1890 (Fisher). [Herb. U. S.]

UROMYCES EUPHORBIÆ, C. & P.

On *Euphorbia dentata*, Putnam, 9, 1891.

On *Euphorbia Preslii*, Johnson, 7, 1890 (Fisher); Fulton, 10, 1893.

On *Euphorbia hypericifolia*, Putnam, 10, 1891; Tippecanoe, 9, 1888 (Bolley).

UROMYCES GRAMINICOLA Burrill.

II. III. On some grass (*Triodia?* or *Glyceria?*), Johnson, 8, 1890 (Fisher). [Herb. U. S.]

UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.

On *Desmodium canescens*, Johnson, 7, 1890 (Fisher); Montgomery, 1893 (Olive).

On *Desmodium laevigatum*, Montgomery, 7, 1890 (Fisher).

On *Desmodium paniculatum*, Johnson, 7, 1890; 10, 1890 (Fisher).

On *Desmodium viridiflorum*, Putnam, 9, 1893.

On *Desmodium Dillenii*, Montgomery (Rose).

On *Desmodium* sp., Owen, 10, 1893; Vigo, 10, 1893; Marshall, 10, 1893; Montgomery, 10, 1893.

UROMYCES HOWEI Pk.

On *Asclepias cornuti*, Johnson, 8, 1890 (Fisher); Montgomery, 7, 1890 (Fisher); 1893 (Olive); 10, 1893; Putnam, 10, 1891; 9, 1893; Wabash, 7, 1891 (Miller); Dearborn 9, 1888 (Bolley).

On *Asclepias purpurascens*, Montgomery, 10, 1890 (Fisher).

On *Asclepias incarnata*, Montgomery, 1893 (Olive).

UROMYCES HYPERICI (Schw.) Curt.

On *Elodes campanulata*, Marshall, 10, 1893.

On *Hypericum Canadense*, Johnson, 8, 1890 (Fisher).

On *Hypericum mutilum*, Putnam, 10, 1891; Marshall, 10, 1893.

UROMYCES LESPEDEZÆ (Schw.) Pk.

On *Lespedeza procumbens*, Montgomery, 10, 1890 (Fisher).

On *Lespedeza reticulata*, Montgomery, 10, 1890 (Fisher).

On *Lespedeza* sp., Owen, 10, 1893.

UROMYCES PERIGYNIUS Hals.

On *Carex pubescens*, Putnam, 5, 1890 (Arthur). Cf. Bot. Gaz., Aug. 1891.

UROMYCES POLYGONI (Pers.) Fuckel.

On *Polygonum acre*, Johnson, 8, 1890 (Fisher).

On *Polygonum aviculare*, Putnam, 9, 1893; Montgomery, 1893 (Olive);

Tippecanoe, 9, 1888 (Bolley).

On *Polygonum erectum*, Johnson, 8, 1890 (Fisher); Putnam, 10, 1891;
Tippecanoe, 9, 1888 (Bolley).

UROMYCES TEREBINTHI (D C.) Wint.

On *Rhus toxicodendron*, Montgomery, 10, 1890 (Fisher); Putnam, 9, 1893;
10, 1893; Owen, 10, 1893.

UROMYCES TRIFOLII (A. & S.) Wint.

On *Trifolium medium*, Johnson, 11, 1890 (Fisher).

On *Trifolium pratense*, Montgomery, 10, 1890 (Fisher); 1893 (Olive);
Johnson, 11, 1890 (Fisher); Putnam, 9, 1891; Tippecanoe, 10, 1891
(Arthur); Wabash, 8, 1891 (Miller).

On *Trifolium repens*, Montgomery, 1893 (Olive); Tippecanoe, 10, 1888
(Bolley).

On *Trifolium hybridum*, Wabash, 10, 1886 (Miller).

UROMYCES sp.

On *Carex lupulina pedunculata*, Johnson, 11, 1890 (Fisher).

"n. sp." [Herb. U. S.]

UROPYXIS AMORPHÆ (Curt.) Schrot.

On *Amorpha canescens*, Marshall, 10, 1893.

TREMELLINI.

AURICULARIA SAMBUCINA Mart. Putnam, 12, 1891; 5, 1893; 10, 1893.

EXIDIA GLANDULOSA Bull. Putnam, 12, 1891; 10, 1893.

GUEPINIA SPATHULARIA Schw. Putnam, 10, 1892; 9, 1893.

TREMELLA ALBIDA Huds. Putnam, 6, 1893 (M. T. Cook.)

TREMELLA FOLIACEA Pers. Putnam, 10, 1893.

TREMELLA LUTESCENS Pers. Putnam, 10, 1893.

HYMENOMYCETES.

THELEPHOREI.

CORTICIUM INCARNATUM Fr.

On *Hicoria* sp., Putnam, 4, 1893.

CORTICIUM MUTATUM Pk., Putnam, 10, 1891.

CRATERELLUS CORNUCOPIOIDES L. Putnam, 7, 1893.

STEREUM ALBOBADIUM Schw., Putnam, 10, 1891 (H. E. Cole).

STEREUM BICOLOR Pers? Putnam, 10, 1891.

STEREUM COMPLICATUM Fr., Putnam, 10, 1891.

STEREUM FRUSTULOSUM Pers.

On *Quercus* sp., Putnam, 10, 1891; 10, 1892; 10, 1893.

STEREUM PURPUREUM Pers., Putnam, 3, 1892.

STEREUM SERICEUM Schw., Putnam, 10, 1891.

STEREUM VERSICOLOR Swartz, Putnam, 10, 1891; 10, 1892; 11, 1893.

THELEPHORA SCHWEINITZII Pk., Putnam, 7, 1893.

CLAVARIEI.

CAIOCERA CORNEA Batsch. Putnam, 11, 1892; 10, 1893.

CLAVARIA CRISPULA Fr. Putnam, 7, 1893; 10, 1893.

CLAVARIA MUCIDA Pers. Putnam, 10, 1893.

CLAVARIA PYXIDATA Pers. Putnam, 10, 1893; Marshall, 10, 1893.

CLAVARIA STRICTA Pers. Putnam, 10, 1893.

HYDNEI.

HYDNUM ALBOVIRIDE Morg. Putnam, 6, 1893 (Florence Young).

HYDNUM ALUTACEUM Fr. Putnam, 10, 1891.

HYDNUM CORALLOIDES Scop. Putnam, 9, 1891; 12, 1891; 10, 1893 (Ellis and Wright); Tippecanoe, 9, 1893 (Arthur).

HYDNUM ERINACEUM Bull. Putnam, 10, 1891; 10, 1893; Vermillion, 9, 1889 (Arthur).

HYDNUM FARINACEUM Pers. Putnam, 10, 1891; 10, 1893.

HYDNUM FLABELLIFORME Berk. Putnam, 10, 1893.

HYDNUM MUCIDUM Fr. Putnam, 12, 1891.

HYDNUM NUDUM B. and C. Putnam, 11, 1891.

HYDNUM OCHRACEUM P. Putnam, 10, 1891; 10, 1893; Vigo, 10, 1893.

HYDNUM PITHYOPHILUM B. & C. ? Putnam, 10, 1893; plant bright yellow.

HYDNUM PULCHERRIMUM B. & C. Putnam, 10, 1891.

HYDNUM SEPTENTRIONALE Fr.

On a fallen oak, Vigo, 10, 1893.

On a standing beech, Vigo, 10, 1893.

HYDNUM STRATOSUM Berk. Under side of a log, Putnam, 10, 1891.

HYDNUM UDUM Fr. Putnam, 10, 1892; 10, 1893.

IRPEX FUSCESCENS Schw. Vigo 10, 1893; Putnam, 10, 1893.

IRPEX OBLIQUUS Schrad. Vigo, 10, 1893.

PILEBIA MERISMOIDES Fr. Putnam, 10, 1892; 10, 1893; Vigo, 10, 1893.

POLYPORINEE.

DEDALEA AMBIGUA Berk. Putnam, 9, 1891; 10, 1893.

DEDALEA CONFRAGOSA Bolt. Putnam, 10, 1891; 9, 1893.

DEDALEA UNICOLOR Bull. Putnam, 10, 1893.

FAVOLUS ALVEOLARIUS (D C.) Fairman. (*F. Europaeus*, *F. Canadensis*.) Putnam, 1, 1893; Marshall, 10, 1893.

GLÆOPORUS CONCHOIDES Mont. ? Vigo, 10, 1893; Tippecanoe, 4, 1892 (Arthur).

LENZITES BETULINA (L.) Fr. Putnam, 10, 1891; Vigo, 10, 1893; Tippecanoe, 4, 1892 (Arthur).

LENZITES VIALIS Pk. Putnam, 10, 1891; 10, 1893 (Including polyporoid forms.)

MERULIUS MOLLUSCUS Fr. Putnam, 10, 1893.

MERULIUS RUBELLUS Pk. Putnam, 9, 1891; 11, 1892; 10, 1893.

MERULIUS TREMELLOSUS Schrad. Putnam, 10, 1891; 5, 1893; 11, 1893; Vigo, 10, 1893.

POLYPORUS ADUSTUS Willd. Putnam, 10, 1891; 10, 1893; Vigo, 10, 1893.

POLYPORUS APPLANATUS Pers. Putnam, 10, 1891; 10, 1892; 10, 1893; Tippecanoe, 4, 1890 (Arthur).

POLYPORUS ARCULARIUS Batsch.

On fallen branches, Putnam, 5, 1892; 5, 1893.

POLYPORUS CONCHIATUS (Pers.) Fr. Putnam, 10, 1893.

POLYPORUS CONCHIFER Schw.

On branches of *Ulmus Americana*, Putnam, 10, 1891; 10, 1893.

POLYPORUS CONNATUS Fr.

On cherry tree, Putnam, 3, 1893.

POLYPORUS FRAXINOPHILUS Pk.

On *Fraxinus Americana*, Putnam, 5, 1893.

POLYPORUS FUSCOCARNEUS Pers. Putnam, 10, 1893; 11, 1893.*

POLYPORUS GILVUS Schw. Putnam, 10, 1891; Vigo, 10, 1893; Marshall, 10, 1893.

POLYPORUS HIRSUTUS Wulf. Putnam, 10, 1891; 10, 1892; 10, 1893.

POLYPORUS OBducENS Pers. Putnam, 10, 1891.

POLYPORUS PERGAMENUS Fr. Putnam, 10, 1891; 12, 1891; 10, 1892; Tippecanoe, 1889 (Arthur).

POLYPORUS PICIPES Fr. Putnam, 10, 1891.

POLYPORUS RADICATUS Schw. Putnam, 10, 1891.

POLYPORUS RESINOSUS Schrad.

On *Tilia Americana*, Putnam, 5, 1892; 10, 1892.

POLYPORUS RIBIS (Schum.) Fr.

On currant bushes, Putnam, 5, 1893.

POLYPORUS RIMOSUS Berk ? Putnam, 10, 1891.

POLYPORUS SULPHUREUS (Bull.) Fr. Putnam, 9, 1893.

*These forms are called by Peck var. *tennis*.

POLYPORUS VERSICOLOR (L.) Fr. Tippecanoe, 11, 1889 (Arthur); Putnam, 10, 1891; Vigo, 10, 1893.

POLYPORUS VITELLINUS Schw. Putnam, 11, 1892.

POLYPORUS VITREUS Pers? Vigo, 10, 1893.

POLYPORUS (*Poria*) **XANTHOSPORUS** n. sp. A resupinate plant with golden yellow spores, covering large areas of decaying wood; mycelium thin, dirty white, forming an almost imperceptible subiculum; pores at first whitish shallow folds of the subiculum, leaving scarcely any margin not occupied by the various stages of imperfectly formed pores, at length appearing yellowish from the abundant spores, finally yellowish brown or dark russet, slightly angular, small (0.25 mm.), becoming cristate at the mouth, 1 cm. or less long when fully mature, or with occasional longer masses of pores rising above the general surface, 2-2.5 cm. long; spores copious, brilliant golden yellow, oval, smooth, nucleate, 6x4 or 6x5 mic. "Goose pond" nine miles south of Terre Haute, Vigo county, October 1893. Forming large masses in cavities underneath the bark and wood of decaying poplar logs (*Populus heterophylla*?), its brilliant spores forming a dense covering in portions of the cavities not filled with the fungus. The color has persisted without appreciable fading after exposure to the light for nearly seven months.

TRAMETES CINNABARINA (Jacq.) Fr. Putnam, 10, 1891; 10, 1893; Tippecanoe, 5, 1893 (Arthur); Vigo, 10, 1893; Marshall, 10, 1893.

TRAMETES SCUTELLATA Schw. (*T. Ohiensis* Berk.)

On oak rails, Putnam, 11, 1891.

BOLETINEÆ.

BOLETINUS POROSUS (Berk.) Pk. Putnam, 10, 1893.

BOLETUS AMERICANUS Pk. Putnam, 9, 1891.

BOLETUS CLINTONIANUS Pk. In a tamarack swamp, Fulton, 10, 1893.

BOLETUS SUBLUTEUS Pk. Putnam, 10, 1893.

BOLETUS SUBTOMENTOSUS L. Putnam, 7, 1893.

AGARICINEÆ.

AGARICUS CAMPESTRIS L. Putnam, 10, 1891; 5, 1892; 9, 1893.

AGARICUS SYLVATICUS Schæff. Putnam, 10, 1893.

AMANITA MUSCARIA L. Putnam, 7, 1893.

AMANITA PANTHERINA D. C. Putnam, 7, 1893.

AMANITA PHALLOIDES Fr. Putnam, 9, 1893.

AMANITA VIROSA Fr. In low, sandy woods, Vigo, 10, 1893.

ARMILLARIA MELLEA Vahl. Putnam, 9, 1891; 9, 1893; 10, 1893.

- CLITOCYBE ILLUDENS Schw. Putnam, 10, 1893.
- CLITOCYBE LACCATA Scap. Putnam 9, 1891; Vigo, 10, 1893.
- CLITOCYBE PHYLLOPHILA Fr. Putnam, 10, 1893.
- COLLYBIA DRYOPHILA Bull. Putnam, 5, 1892.
- COLLYBIA LONGIPES Bull. Putnam, 10, 1893.
- COLLYBIA PLATYPHYLLA Fr. Putnam, 5, 1892.
- COLLYBIA RADICATA Relh. Putnam, 9, 1891; 10, 1893.
- COLLYBIA VELUTIPES Curt. Putnam, 12, 1891; Tippecanoe, 4, 1892. (Arthur).
- CREPIDOTUS DORSALIS Pk. Putnam, 10, 1891.
- CREPIDOTUS FULVOTOMENTOSUS Pk. Putnam, 7, 1893; 10, 1893.
- GALERA TENERA Schæff. Putnam, 10, 1893.
- HYPHOLOMA CANDOLLEANUM Fr.
- On lawns, Putnam 6, 1893.
- HYPHOLOMA INCERTUM Pk. Putnam, 5, 1892.
- HYPHOLOMA SUBLATERITUM Schæff. Putnam, 10, 1891; 10, 1893.
- HYPHOLOMA VELUTINUM Pers. Putnam, 10, 1893.
- LEPIOTA AMERICANA Pk. Putnam, 9, 1893.
- LEPIOTA CRISTATA A. and S. Putnam, 9, 1893.
- LEPIOTA NAUCINOIDES Pk. Putnam, 10, 1893.
- LEPIOTA PROCERA Scop. Putnam, 10, 1893; Montgomery, 10, 1893.
- MYCENA CORTICOLA Schum.
- On bark of living trees, Putnam, 11, 1891.
- MYCENA GALERICULATA Scop. Putnam, 5, 1892; Vigo, 5, 1893.
- MYCENA LEAIANA Berk. Putnam, 5, 1892; Vigo, 5, 1893.
- NAUCORIA SEMIORBICULARIS (Bull).
- On lawns, Putnam, 5, 1892.
- PANÆOLUS FIMIPUTRIS Bull.
- On dung in pastures, Putnam, 6, 1893.
- PHOLIOTA ADIPOSA Fr. Putnam, 9, 1893; Vigo, 10, 1893.
- PHOLIOTA SPECTABILIS Fr. Vigo, 10, 1893.
- PLEUROTUS SALIGNUS Schrad.
- On dead Salix, Putnam, 10, 1893.
- PLEUROTUS SEROTINUS Schrad. Putnam, 11, 1892.
- PLUTEUS CERVINUS Schæff. Putnam, 5, 1892; 9, 1893.
- STROPHARIA ERUGINOSA Curt. Putnam, 10, 1893; Vigo, 10, 1893.
- STROPHARIA SEMIGLOBATA Batsch. Putnam, 10, 1893.
- TUBARIA FURFURACEA Pers. Putnam, 10, 1893.
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BOLBITIUS TENER Berk.

On lawns, Putnam 6, 1893.

CANTHARELLUS CIBARIUS Fr. Putnam, 7, 1893.

CANTHARELLUS CINNABARINUS. Putnam, 7, 1893.

COPRINUS ATRAMENTARIUS (Bull.) Fr. Putnam, 4, 1892; 10, 1893.

COPRINUS COMATUS Fr. Putnam, 10, 1893.

COPRINUS MICACEUS (Bull.) Fr. Putnam 4, 1892.

COPRINUS Plicatilis (Curt.) Fr. Putnam, 6, 1893 (Melia Ellis).

COPRINUS STERQUILINUS Fr. Putnam, 6, 1893 (Melia Ellis).

LACTARIUS TRIVIALIS Fr. Putnam, 7, 1893.

LENTINUS LEPIDEUS Fr. Vigo, 10, 1893.

LENTINUS STRIGOSUS Fr. Putnam, 10, 1891; 10, 1893.

MARASMIUS ROTULA (Scop.) Fr. Putnam, 5, 1893.

PANUS STYPTICUS (Bull.) Fr. Putnam, 10, 1891; 5, 1893; 10, 1893; Vigo, 10, 1893.

SCHIZOPHYLLUM COMMUNE Fr. Putnam, 10, 1891; 11, 1893; Montgomery, 10, 1893.

GASTROMYCETES.**PHALLOIDÆÆ.**

MUTINUS CANINUS Huds. Putnam, 6, 1893; 7, 1893.

PHALLUS DEMONUM Rumph. ? Putnam, 10, 1891.

PHALLUS DUPLICATUS Bosc. Putnam, 10, 1891.

PHALLUS RAVENELII B. & C. Putnam 10, 1891.

LYCOPERDACEÆ.

BOVISTA MINOR Morg. Putnam, 4, 1894.

BOVISTA PILA B & C. Putnam, 4, 1892; 10, 1893; Marshall, 10, 1893.

BOVISTA PLUMBEA Pers. Vermillion, 9, 1889 (Arthur); Putnam, 6, 1892.

CALVATIA BOVISTA (L.) (C. maxima Schæff., Lycoperdon gigantum Batch).
Montgomery, 4, 1892 (Blair); Noble, 9, 1892 (Laura Beazell); Putnam, 11, 1893.

CALVATIA CÆLATA Bull. Putnam, 10, 1893.

CALVATIA CRANIIFORMIS Schw. Putnam, 10, 1893; Owen, 10, 1893.

CALVATIA CYATHIFORMIS Bosc. Putnam 4, 1893; 10, 1893; 11, 1893; Vigo, 10, 1893; Vermillion (Arthur).

CATASTOMA CIRCUMSCISSUM (B. & C.) Morg. Putnam 9, 1893.

GEASTER CAPENSIS Thüm. Elkhart 6, 1892. (S. W. Baer).

GEASTER LIMBATUS Fr. Putnam, 12, 1892.

GEASTER STRIATUS D. C. Putnam, 4, 1892; 10, 1892.

LYCOPERDON ASTEROSPERMUM D. & M. Vigo 10, 1893.*

LYCOPERDON CEPÆFORME Bull. Putnam 9, 1893.

LYCOPERDON COLORATUM Pk. Putnam 4, 1894.

LYCOPERDON EXCIPULIFORME Scop. Putnam, 10, 1893.*

LYCOPERDON GLABELLUM Pk. Putnam, 10, 1893.

LYCOPERDON GEMMATUM Batsch. Putnam, 10, 1893.

LYCOPERDON MUSCORUM Morg. Vigo, 5, 1893 (a single specimen).

LYCOPERDON PECKII Morg. Marshall, 10, 1893; Vigo, 10, 1893.

LYCOPERDON PEDICELLATUM Pk. Putnam, 10, 1893.

LYCOPERDON PYRIFORME Schæff. Putnam, 10, 1893; Vigo, 10, 1893.

LYCOPERDON RIMULATUM Pk. Vigo, 5, 1893 (one specimen only).

LYCOPERDON SEPARANS Pk. Putnam, 10, 1893; Marshall, 10, 1893; Vigo, 10, 1893.

LYCOPERDON TURNERI E. and F. Marshall, 10, 1893.*

SECOTIUM ACCUMINATUM (Mont.) Tul. (S. *Warnei* Pk.) Putnam, 10, 1893;
Tippecanoe, 9, 1893 (Arthur).

TYLOSTOMA MAMMOSUM Mich. Putnam, 4, 1892; Vigo, 5, 1893.

SCLERODERMACEÆ.

SCLERODERMA VULGARE Fr. Putnam, 9, 1893.

NIDULARIACEÆ.

CRUCIBULUM VULGARE Tul. Brown, 5, 1893; Putnam, 6, 1893; 9, 1893;
Vigo, 10, 1893.

CYATHUS STRIATUS (Huds.) Hoffm. Putnam, 7, 1893.

CYATHUS VERNICOSUS (Bull.) D C. Vermillion, 9, 1889 (Arthur); Putnam,
6, 1893; 9, 1893.

BRYOPHYTA.

HEPATICÆ.

RICCIACEÆ.

RICCIA FLUITANS L. Marshall, 5, 1891 (Norman); St. Joseph, 7, 1893 (Uline);
Vigo, 5, 1893.

MARCHANTIACEÆ.

ASTERELLA HEMISPHERICA (L.) Beauv. Putnam, 5, 1891 (Campbell); 5, 1892;
10, 1892.

CONOCEPHALUS CONICUS (L.) Dumort. Putnam 10, 1892.

FIMBRIARIA TENELLA Nees. Owen, 5, 1893; Brown, 5, 1893.

MARCHANTIA POLYMORPHA L. Putnam, 5, 1892; Owen, 5, 1893; Fulton, 10,
1893.

*Determined by A. P. Morgan.

ANTHOCEROTACEÆ.

ANTHOCEROS LEVIS L. Putnam, 10, 1892.

NOTHOTHYLAS ORBICULARIS (Schw.) Sulliv. Putnam, 11, 1892; Monroe, 1893 (Mottier).

JUNGERMANIACEÆ.

ANEURA PINGUIS (L.) Dumort. Putnam, 11, 1892 (one specimen only).

BAZZANIA TRILOBATA (L.) S. F. Gray. Putnam, 10, 1891.

CEPHALOZIA CURVIFOLIA (Dicks.) Dumort. Putnam, 3, 1892; 10, 1892.

CHILOSCYPHUS ASCENDENS H. and W. Putnam, 3, 1891.

DIPLOPHYLLUM TAXIFOLIUM (Wahl.) Dumort. Putnam, 10, 1892.

FOSSEMBRONIA CRISTATA Lindb. Putnam, 10, 1891.

FRULLANIA LEOLOTIS Nees. Putnam, 10, 1891.

FRULLANIA EBORACENSIS Lehm. Putnam, 10, 1891.

FRULLANIA SQUARROSA Nees. Putnam, 10, 1891.

FRULLANIA VIRGINICA Lehm. Putnam, 10, 1891.

GEOCALYX GRAVEOLENS (Schrader.) Nees. Putnam, 10, 1892.

JUNGERMANIA SCHRADERI Mart. Montgomery, 4, 1892.

LEJEUNEA CALCAREA Lib. Putnam, 10, 1891. (On *Camptosorus*.)

LEPIDOZIA REPTANS (L.) Dumort. Putnam, 3, 1892; 10, 1892.

LOPHOCOLEA HETEROPHYLLA (Schrader.) Nees. Montgomery, 4, 1892.

LOPHOCOLEA BIDENTATA (L.) Dumort. Putnam, 10, 1892.

NARDIA CRENULATA (Sm.) S. F. Gray. Putnam, 10, 1893.

NARDIA HYALINA (Lyell) Carr. Putnam, 5, 1893.

PELLIA EPIPHYLLA (L.) Raddi. Putnam, 10, 1891; 10, 1892.

PORELLA PINNATA L. Vigo, 5, 1893.

PORELLA PLATYPHYLLA (L.) Lindb. Putnam, 10, 1891; Monroe, 5, 1893.

PLAGIOCHILA ASPLENOIDES (L.) Dumort. Putnam 10, 1892.

PTILIDIUM CILIARE (L.) Nees. Putnam, 10, 1891.

SCAPANIA NEMOROSA (L.) Dumort. Putnam, 9, 1891; 10, 1892.

TRICHOCOLEA TOMENTELLA (Ehrh.) Dumort. Putnam 4, 1892.

MUSCI.

ANOMODON ROSTRATUS (Hedw.) Schimp. Owen, 5, 1893; Montgomery (Barnes).

ATRICHUM ANGUSTATUM (Brid.) Bruch. & Schimp. Vigo, 10, 1893.

ATRICHUM UNDULATUM (L.) Bruch. & Schimp. Putnam, 9, 1891.

AULACOMNIUM HETEROSTICHUM (Beauv.) Bruch. & Schimp. Putnam, 5, 1893; Montgomery (Barnes).

- BARTRAMIA POMIFORMIS** (L.) Hedw. Putnam, 10, 1891.
BRYUM ARGENTEUM L. Putnam, 2, 1892.
BRYUM CESPITICUM L. Putnam, 5, 1892.
BRYUM INTERMEDIUM (Schwäg.) Brid. Owen, 5, 1893.
BRYUM ROSEUM Schreb. Putnam, 10, 1893.
CERATODON PURPUREUS (L.) Brid. Tippecanoe, 4, 1892; Owen, 5, 1893; Putnam, 4, 1894.
CLIMACIUM AMERICANUM Brid. Putnam, 10, 1891; 10, 1892.
CONOMITRIUM JULIANUM (Savi.) Mont. Monroe, 3, 1893 (Mottier).
CYLINDROTHECIUM CLADORRHIZANS (Hedw.) Schimp. Putnam, 10, 1891; 5, 1893.
DICRANELLA HETEROMALLA (L.) Schimp. Putnam, 10, 1891; Lake (Röll).
DICRANELLA RUFESCENS (Turn.) Schimp. Putnam, 10, 1891.
DICRANELLA VARIA (Hedw.) Schimp. Putnam, 11, 1892.
DICRANUM FLAGELLARE Hedw. Lake (Röll). [Herb. Barnes.]
DICRANUM SCOPARIUM (L.) Hedw. Putnam, 10, 1891; 5, 1893.
DRUMMONDIA CLAVELLATA Hook. Tippecanoe, 4, 1892; Monroe (Blatchley).
EUSTICHIA NORVEGICA Brid.
 On sandstone rocks. Putnam, 10, 1891.
FISSIDENS INCURVUS (W. and M.) Schwäg. Putnam, 12, 1892.
FISSIDENS TAXIFOLIUS (L.) Hedw. Putnam, 5, 1893.
FUNARIA HYGROMETRICA (L.) Sibth. Putnam, 5, 1892.
GRIMMIA APOCARPA (L.) Hedw. Putnam, 5, 1893.
GYMNOSTOMUM CURVIROSTRE Hedw. Owen, 5, 1893.
HYPNUM (Thamnium) ALLEGHANIENSE Müll. Putnam, 4, 1892.
HYPNUM ARCUATUM. Montgomery (Barnes). [Herb. Barnes.]
HYPNUM (Eurhynchium) BOSCHII Schwäg. Putnam, 10, 1891; Monroe (Blatchley).
HYPNUM (Euhypnum) CUPRESSIFORME L. Putnam, 10, 1891; 5, 1893.
HYPNUM (Thuidium) DELICATULUM L. Putnam, 10, 1891.
HYPNUM (Amblystegium) FLUVIATILE, Swartz. Montgomery (Barnes); Putnam, 5, 1882.
HYPNUM (Brachythecium) LETUM Brid. Montgomery (Barnes); Putnam, 10, 1891.
HYPNUM (Amblystegium) RADICALE Beauv. Montgomery (Barnes). [Herb. Barnes.]
HYPNUM (Brachythecium) RUTABULUM L. Putnam, 10, 1891.
HYPNUM (Rhynchostegium) SERRULATUM Hedw. Putnam, 9, 1891; 5, 1893.

- HYPNUM (Amblystegium) SERPENS** L. Putnam, 5, 1893.
LEPTOTRICHUM PALLIDUM (Herb.) Hampe. Vigo, 5, 1893.
LEPTOTRICHUM TORTILE (Schrader.) Müll. Lake (Roll). [Herb. Barnes.]
LEUCOBRYUM VULGARE Hampe. Fulton, 10, 1893; Putnam, 10, 1893.
LEUCODON JULACEUS (Hedw.) Sulliv. Monroe (Blatchley); Putnam, 10, 1891; 12, 1891.
MNIUM AFFINE Bland. Montgomery (Barnes). [Herb. Barnes.]
MNIUM CUSPIDATUM Hedw. Putnam, 5, 1892.
PHYSCOMITRIUM TURBINATUM (Michx.) Brid. Putnam, 5, 1892; 5, 1893; Tippecanoe, 4, 1892; Owen; 5, 1893.
POGONATUM BREVICAULE Beauv. Putnam, 10, 1892.
POLYTRICHUM FORMOSUM Hedw. Montgomery (Barnes). [Herb. Barnes.]
POLYTRICHUM OHIOENSE Ren. & Cardot. Marshall, 10, 1893.
POTTIA TRUNCATA (Hedw.) Fuern. Tippecanoe, 4, 1892.
TIMMIA MEGAPOLITANA Hedw. Montgomery (Barnes). [Herb. Barnes.]
WEISIA RIVIDULA Brid. Putnam, 4, 1892.

SPHAGNACEÆ.

- SPHAGNUM CYMBIFOLIUM** Ehrh. Fulton, 10, 1893.*
SPHAGNUM PAPILLOSUM LÉVE Warnst. Fulton, 10, 1893.*
SPHAGNUM RECURVUM MUCRONATUM. Fulton, 10, 1893.*
SPHAGNUM RUFESCENS. Fulton, 10, 1893.*

* Determined by Prof. D. C. Eaton.

ZOOLOGY.

C. H. EIGENMANN, DIRECTOR.

In connection with the general circular of the Biological Survey of Indiana, the following special circular for the Zoological section was issued:

SPECIAL ANNOUNCEMENT OF THE DIVISION OF ZOOLOGY.

The leading aim of this division during the season will be the compilation of a complete bibliography of the vertebrates of Indiana and of as many invertebrates as can be provided for.

At the same time any material showing the distribution of animals in the state is especially desirable. To determine the distribution, complete collections of the vertebrates of as many localities as possible should be

made. Collections should always accompany notes, so that the observations may be verified by some specialist.

No opportunity should be neglected to observe the breeding habits and seasons, and the animal with young should, whenever possible, be preserved and forwarded to the Director, who will transmit it to the proper authority for record.

Another subject which should receive attention is the migration, or seasonal appearance and disappearance of mammals, birds, reptiles and fishes. The interesting results obtained in the observation of the migration of birds only suggest what may be done with the less conspicuous but no less interesting habits of other forms.

CARL H. EIGENMANN, Director,
Bloomington, Indiana.

The chief aim of this division for the past season—the compilation of the bibliography of the vertebrates of Indiana—has been completed, and, wherever that has not been done before, preliminary lists of the Indiana species have been compiled and are ready for the printer. Where such lists had recently been published in accessible form they have not been reproduced.

I give here the titles of the lists of species and bibliographies with their place of publication :

A CATALOGUE OF THE MAMMALS OF INDIANA, WITH BIBLIOGRAPHY.

A. W. Butler and B. W. Evermann. These proceedings.

A CATALOGUE OF THE BIRDS OF INDIANA.

Amos W. Butler. Proceedings of the Agricultural Society, 1890.

BIBLIOGRAPHY OF INDIANA ORNITHOLOGY.

A. W. Butler. These proceedings.

THE BATRACHIANS AND REPTILES OF THE STATE OF INDIANA.

O. P. Hay. Seventeenth Report Indiana Geological and Natural History Survey.

BIBLIOGRAPHY OF THE BATRACHIANS AND REPTILES OF INDIANA.

O. P. Hay. These proceedings.

A CATALOGUE OF THE FISHES OF INDIANA.

Carl H. Eigenmann and C. H. Beeson. These proceedings.

BIBLIOGRAPHY OF INDIANA ICHTHYOLOGY.

Carl H. Eigenmann. These proceedings.

The invertebrates have not been so well provided for, although some of the groups have received an equal share of attention.

No reports on the Protozoa, sponges, Plathelminthes and Vermes have been prepared.

A catalogue of the Mollusca with bibliography has been completed by Mr. R. Elsworth Call, and appears in these proceedings.

Several groups of the Arthropods have recently been dealt with.

In the Memorial Bulletin (No. 46, 1893) of the U. S. National Museum, the complete writings of our late associate, Harvey Bollman, have been reproduced. In this volume the Indiana Myriopoda are more fully treated than those of any other state. In the same volume, L. M. Underwood has given a complete bibliography of the American Myriopoda, and naturally, the Indiana bibliography is included.

A CATALOGUE OF THE BUTTERFLIES KNOWN TO OCCUR IN INDIANA.

W. S. Blatchley. Seventeenth Annual Report Indiana Geological and Natural History Survey.

THE GRYLLIDE OF INDIANA.

W. S. Blatchley. Proc. Indiana Academy I, 126.

THE LOCUSTIDE OF INDIANA.

W. S. Blatchley. Proc. Indiana Academy II, 92.

THE BLATTIDE OF INDIANA.

W. S. Blatchley. Proc. Indiana Academy II, 153.

A PARTIAL LIST OF NEW SPECIES OF PARASITIC HYMENOPTERA REARED IN INDIANA.

F. M. Webster. Proc. Indiana Academy II, 89.

The Crustacea of Indiana have been considered by O. P. Hay in the proceedings of the Indiana Academy I, 147.

Hereafter all specimens coming into the hands of the Academy will be referred to the following specialists:

Mammals and Birds	A. W. Butler.
Batrachians and Reptiles	O. P. Hay.
Fishes	Carl H. Eigenmann.
Lepidoptera and Orthoptera	W. S. Blatchley.
Crustacea	W. P. Hay.
Animal Parasites	A. W. Bitting.
Arachnida	Dr. Henry C. McCook.

The field work for the past two seasons has been limited to private enterprise except as far as the explorations of the U. S. Fish Commission were concerned.

The specialists in the various branches will record the details of the progress in their respective departments.

The work in fishes has been as follows:

Mr. D. C. Ridgely has collected for the Indiana University in Trail creek, a small stream of La Porte county, emptying into Lake Michigan. Mr. W. O. Wallace has collected a good series of fishes in Wabash county. Messrs. Kirsch and Beeson on behalf of the U. S. Fish Commission have explored the Eel river along its entire length and made collections in various points of the Maumee basin.

Offers of assistance and co-operation have been received from various persons over the state who have not yet given any concrete assistance.

It is the intention of the director of the Zoological Survey to establish stations at various places in the state during successive summers to study the fauna in situ. The work during the coming summer will either be explorations along the Ohio river or on one of the lakes of northern Indiana. Next to the distribution of Indiana organisms their correlation in different localities, their geographical variations, migrations and breeding habits seem to be questions which should be studied.

The position and general features of Indiana are such that not a single animal need be expected to be restricted within its geographical boundaries. The same may be said of the four states surrounding it. Nor would they with Indiana form a geographical unit. For these reasons it seems to me that the advantages of co-operation with neighboring states may be overestimated. If the survey is to be restricted by geographical boundaries, the boundaries of Indiana will do about as well as the boundaries of the states surrounding us. While too great value can not be placed on the thorough exploration of neighboring states and of the states bordering on them for purposes of comparison, our best efforts, must for economic reasons, be devoted to our own bailiwick.

This leads me to say a word in favor of county surveys. The same interests that bind us together to conduct a survey of the state unite the teachers and others of the same county and through this common interest county surveys may be established and the survey of the state furthered. I am well aware that animals and plants do not respect county lines, but neither do they state lines. I would urge the formation of county science associations whose sole purpose it shall be to make a careful survey of the respective counties. Wabash county has such an association, and judging the work of this association from the part that has passed through my hands, this association may well form a model for other counties.

Teachers and others of this county formed an association similar to that of the Academy of Sciences. Some one interested in a particular branch was made curator of that branch and all specimens referred to him. As a result we have a very fair collection of the fishes of this county with exact locality labels, a complete set of the birds, including several not known to occur elsewhere in the state, (*Dendraca kirtlandi*) and a similar list of the plants. Work as well done as this in every county of the state would rapidly advance our knowledge of the habits and distribution of the organisms in the state.

Those counties in which academies, colleges or universities are situated ought to lead in this respect. It is certainly the duty of the biological departments of such institutions to make a survey of the surrounding country and *display its fauna and flora*. While I deprecate the miscellaneous collections of odds and ends from nowhere and the ends of the world, a systematic collection of the organisms displayed with proper labels showing the geographical distribution would have a definite, scientific and educational value. The data for the geographical distribution of Indiana animals will be furnished in the reports of the survey.

BIBLIOGRAPHY OF INDIANA FISHES.

Indiana has had more than her share of American Ichthyologists; in fact, she has harbored at one time or another nearly as many as all the other states put together.

These have come in two widely separate periods. Rafinesque, the author of the *Ichthyologia Ohiensis*, and Le Sueur, both of whom were for a time at New Harmony, published between 1814 and 1820. While works of a general nature had an indirect bearing on the fishes of Indiana, nothing appeared on the fishes of Indiana between 1820 and 1875. All the more recent work has been due to the presence in Indiana of David Starr Jordan. It may be noted here that Jordan's first Ichthyological venture was the publication of a description of the Sisco of Lake Tippecanoe, in 1875, and his last Indiana effort the description of a new fish from the Tippecanoe river, 1890.

About Jordan there arose a group of his pupils, all of whom have added something to the knowledge of the fishes of the state.

The names of these which owed their inspiration directly or indirectly to Jordan are Copeland, Brayton, Gilbert, Hay, McKay, Rosa Smith

Swain, Evermann, Eigenmann, Fordice, Blatchley, Jenkins, Bollman Kirsch, Shannon and Woolman.

The following is a list of the papers which have appeared :

1814. Rafinesque, Constantine Samuel. "Precis des decouvertes Somiologique."
1817. ———First decade of new North American fishes. Am. Monthly Mag. and Crit. Review, Dec.
1817. Le Sueur, Charles A. A new genus of fishes, of the order abdominales proposed, under the name of *Catostomus*; and the characters of this genus, with those of its species, indicated. Journ. of the Acad. Nat. Sci. Philad. I, 1817, pp. 88-96 and 102-111.
1818. Rafinesque. Description of two new genera of North Am. fishes. Am. Monthly Magazine, etc. Jan. 1818.
- Second decade of new North American fishes, l. c. Jan. 1818.
- Discoveries in Natural History made during a journey through the western region of the United State by Constantine Samuel Rafinesque. Am. Monthly Magazine, etc., Sept. 1818. Dated Falls of Ohio, 20th July, 1813.
1818. Le Sueur. In Trans. Am. Philos. Soc. I., 388.
1818. Rafinesque. Further discoveries in Natural History, made during a journey through the western region of the United States, by Constantine Samuel Rafinesque. Am. Monthly Magazine, etc., Oct. 1818.
- Further account of discoveries in Natural History in the western states by Constantine Samuel Rafinesque. l. c., Oct. 1818.
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THE FISHES OF INDIANA. *

By CARL H. EIGENMANN AND CHARLES H. BEESON.

We have compiled a list of the species of fishes so far found in Indiana. After the names, scientific and common, we give a list of all the Indiana localities and authority for the locality. The dates with the authority taken with the bibliography of Indiana fishes will probably be sufficient to enable anyone to look up any of the citations. In a few cases no date is given with the authority. This indicates that no account has been published of the collections made. I. U. Coll. indicates that specimens from that locality are in the collections of the Indiana University.

The localities are arranged in the same order observed in the list of streams which precedes the list of fishes. We give only those streams in which collections have been made. Following the name of the stream we give the name and date of the recorder for the given stream.

List of Localities Explored.

THE OHIO RIVER.

- White Water River, Brookville, Franklin county—Evermann, 1886.
- Laughery Creek, Milton, Ohio county—Jenkins, 1888.
- Fourteen Mile Creek, Clark county—Jenkins, 1888.
- Big Pigeon Creek, Evansville, Vanderburg county—Jordan, 1889.
- Cypress Swamp, Posey county—Jordan, 1889.

THE WABASH RIVER.

- At Delphi, Carroll county—Evermann and Jenkins, 1888.
- At Terre Haute, Vigo county—Jenkins, 1886.
- At Vincennes, Knox county—Jordan, 1889.
- At New Harmony, Posey county—Jordan, 1889.
- At Mackey's Ferry, Posey county—Jordan, 1889.

* Contributions from the Zoological Department of the Indiana University. No. 9.

UPPER WABASH BASIN.

- Blue, Round, Shriner and Cedar Lakes, Whitley county—Kirsch, 1894.
 Blue River, Columbia City, Whitley county—Jordan, 1892; Kirsch, 1894.
 Eel River, Logansport, Cass county—Jordan, 1891.
 Eel River, throughout its entire course—Kirsch, 1894.
 Tippecanoe Lake, Kosciusko county.
 Tippecanoe River—Jordan, 1877; Evermann and Jenkins, 1888.
 Lake Maxinkuckee, Marshall county—Jenkins, 1888.
 Deer Creeks, Carroll county—Evermann and Jenkins, 1888.
 Wild Cat Creek, Carroll county—Evermann and Jenkins, 1888.
 Honey Creek, Howard county—Evermann and Jenkins, 1888.
 Raccoon Creek, Parke county—I. U. Coll.

LOWER WABASH BASIN.

- West Fork White River, Indianapolis—Jordan, 1877.
 Gosport—Eigenmann.
 Spencer—Jordan, 1889.
 Pike Creek, Madison county—Shannon.
 Bean Blossom Creek, Monroe county—Eigenmann and Fordice, 1885.
 Eel River, Owen county—Jordan 1889.
 Switz City Swamp, Greene county—Gilbert, 1884.
 East Fork White River, Bedford—Gilbert, 1884.
 Blue River, Knightstown—I. U. Coll.
 Flat Rock Creek, Decatur county, and Rushville—Shannon, 1887;
 Rush county, Gilbert, 1884.
 Clifty—Shannon, 1887.
 Sand.
 Little Salt Creek, Franklin county—Evermann and Jenkins, 1888.
 Salt Creek—Gilbert, 1884.
 Clear Creek—Eigenmann.
 Lost River, Orangeville, Orange county—Jordan and Eigenmann.
 Patoka River, Gibson county—Jordan, 1889.
 Black River, Posey county—Jordan, 1889.
 Gresham's Creek, Posey county—Jordan, 1889.
 Big Creek, Posey county—Jordan, 1889.

THE MAUMEE SYSTEM.

- Maumee River—Jordan, Kirsch.
 St. Joseph's River—Kirsch.
 St. Mary's River—Kirsch.

THE ILLINOIS BASIN.

Kankakee River, at Riverside—Bates, 1886; Jordan, 1889.

Yellow River, Plymouth, Marshall county—Jordan, 1889.

LAKE MICHIGAN SYSTEM.

Lake, Michigan City—Bates, 1886; Jordan and Evermann.

Turkey Lake.

St. Joseph's River, Mishawaka—Jordan, 1889.

Trail Creek, LaPorte county—Ridgley, 1892.

Clear and Pine Lakes, LaPorte county—Jordan, 1887.

List of Indiana Fishes and their Distribution.

Class MARSIPOBRANCHII (The Myzonts).

Order HYPEROARTIA (The Lampreys).

Family *Petromyzontidae*.

Ammocetes branchialis (L). Brook Lamprey, Mud Lamprey.

West Fork White river at Indianapolis, Jordan 1877 as *A. niger*; Bean Blossom, Eigenmann and Fordice as *A. apypterus*.

Ichthyomyzon concolor (Kirkland).

Ohio at New Albany, Jordan; Blue river at Wyandotte Cave, I. U. Coll.; Wabash at Delphi, Jenkins and Evermann 1888; at New Harmony, Jordan 1889; Indianapolis, Jordan 1877 as *A. argentatus*.

Class PISCES (The true Fishes).

Order SELACHOSTOMI.

Family *Polyodontidae* (The Paddle-fishes.)

Polyodon spathula (Walbaum). Spoon-bill Cat, Duck-bill Cat.

Ohio at Rockport, Eigenmann; White Water at Brookville, Evermann 1886; Wabash at Delphi, Evermann 1888; at Terre Haute, Jenkins 1886; at New Harmony, Jordan 1889; Lake Manitou, Eigenmann and Norman 1894; Indianapolis, Jordan 1877 as *P. folium*.

Order CHONDROSTEI.

Family *Acipenseridae* (The Sturgeons).

Scaphirhynchus platyrhynchus (Raf.). Shovel nosed Sturgeon.

Ohio, Rafinesque; Wabash at Delphi, Evermann 1888; at Terre Haute, Jenkins 1886.

Acipenser rubicundus Le Sueur. Lake Sturgeon, Rock Sturgeon.

Ohio at Louisville, Jordan and Evermann 1887; at Rockport, Eigenmann; at Terre Haute, Jenkins 1886; at New Harmony, Jordan 1889; Lake Michigan at Michigan City, Bates 1886.

Order RHOMBOGANOIDEA.

Family *Lepisosteidae* (The Gar-fishes).

Lepisosteus osseus (L). Common Gar Pike, Long Nosed Gar, Bill-fish.

Ohio at Rockport, Eigenmann; White Water at Brookville, Evermann 1886; Big Pigeon creek at Evansville, Eigenmann; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at New Harmony, Jordan, 1889; Blue river at Columbia City, Kirsch 1894; Tippecanoe river, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; Loon, Big and Crooked lakes, Kirsch 1894; Indianapolis, Jordan 1877; Gosport, Eigenmann.

Lepisosteus platystomus Rafinesque. Short-nosed Gar-pike.

• Wabash at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lake Manitou, Eigenmann and Norman 1894.

Lepisosteus tristechus (Bloch and Schneider). Alligator Gar.

Wabash at New Harmony, Jordan 1889.

Order CYCLOGANOIDEI.

Family *Amiidae* (The Bow-fins).

Amia calva L. Bow-fin, Mud-fish, Dog-fish.

Wabash at Terre Haute, Jenkins 1886; Blue river, Eel river, and in nearly all its upper tributaries, Kirsch 1894; Lake Maxinkuckee, Jenkins 1888; Switz City swamp, Gilbert 1884.

Order NEMATOGNATHI.

Family *Siluridae* (The Cat-fishes).

Ictalurus furcatus (Le Sueur). Chuckle-headed Cat.

Ohio river, Jordan and Evermann 1887.

Ictalurus punctatus (Rafinesque). Channel Cat, White Cat, Silver Cat.

Ohio river, Rafinesque; White Water at Brookville, Evermann 1886; Laughery creek near Milton, Jenkins 1888; Big Pigeon near Evansville, Jordan 1889; Wabash at Delphi, Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; at Spencer, Jordan, 1889; East Fork White river near Bedford, Gilbert 1884; Patoka river, Gibson county, Black river and Big creek, Jordan 1889.

Ameiurus lacustris (Walbaum). Great Cat-fish, Mississippi Cat, Flannel-mouthed Cat.

Wabash at Delphi, Evermann 1888, as *A. nigricans*; Lake Michigan, Jordan and Evermann 1887, as *A. nigricans*.

Ameiurus natalis (Le Sueur). Yellow Cat.

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, Jenkins 1888; Lower Wabash, Jordan 1877 as *cupreus*; Eel River basin in all the lakes, Kirsch 1894; Tippecanoe river, Jordan 1877 as *cupreus* and 1889; Lake Manitou, Eigenmann and Norman; Lake Maxinkuckee, Jenkins 1888; Deer creeks, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877 as *cupreus*; Bean Blossom, Eigenmann and Fordice 1885; Flat Rock and Clifty creeks, Decatur county; Flat Rock Creek at Rushville, Shannon 1887; Salt creek near Bedford, Gilbert 1884; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877 as *cupreus*, and Clear and Pine lakes, La Porte county.

Ameiurus vulgaris (Thompson).

Ohio, Wabash, and Lake Michigan, Jordan and Evermann 1887.

Ameiurus nebulosus (Le Sueur). Common Bullhead, Horned Pout.

Wabash at Terre Haute, Jenkins 1886; Eel river and its tributary lakes and streams, Kirsch 1894; Tippecanoe river, Jordan 1877; Loon, Big and Crooked lakes, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877; Switz City swamp, Greene county, Gilbert 1884; Trail creek, LaPorte county, Ridgley.

Ameiurus melas (Rafinesque).

Wabash at Terre Haute, Jenkins 1886; Tippecanoe river and Lake Maxinkuckee, Jenkins 1888; Deer creeks, Evermann 1888; Raccoon creek at Mecca, Parke county, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *xanthocephalus*; Bean Blossom creek, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; Switz City swamp, Gilbert 1884; East Fork White river and Salt creek near Bedford, Gilbert 1884; Gresham's creek at New Harmony, Jordan 1889; Trail creek, LaPorte county, Ridgley.

Leptops olivaris Rafinesque. Mud Cat, Flat-headed Cat, Russian Cat, Bashaw, Goujon.

White Water at Brookville, Evermann 1886; Laughery creek at Milton, Ohio county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash river at Terre Haute, Jenkins 1886; Tippecanoe river, Jordan 1877; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork White river near

Bedford, Gilbert 1884; Patoka river, Gibson county, Jordan 1889.

Noturus flavus Rafinesque.

White Water river at Brookville, Evermann 1886; Laughery creek at Milton, Ohio county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Vincennes and New Harmony, Jordan 1889; Eel river, Twelve Mile creek, Kirsch 1894; Deer and Little Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877, and at Spencer, Jordan 1889; Bean Blossom creek, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock creek, Decatur county, Shannon 1887; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877; Clear and Pine lakes, Jordan 1877.

Schilbeodes exilis (Nelson).

Tippecanoe river, Jenkins 1888; Bean Blossom, Eigenmann and Fordice 1885.

Schilbeodes minor (Jordan).

Laughery creek near Milton, Ohio county, Jenkins 1888; Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes and New Harmony, Jordan 1889; Lower Wabash, Jordan 1877; Eel river, middle course, Meredith creek, Kirsch 1894; Tippecanoe and Lake Maxinkuckee, Jordan 1889; Deer and Wild Cat creeks, Evermann and Jenkins 1888; West Fork White river, at Indianapolis, Jordan, 1877; at Gosport, Eigenmann; at Spencer, Jordan, 1889; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock creek, Decatur, county, Shannon 1887; Clear creek, Bloomington, I. U. Coll.; Patoka river, Gibson county Jordan, 1889; Maumee river, Jordan 1877.

Schilbeodes eleutherus (Jordan).

Eel river middle course, Shriner lake, Columbia City, Kirsch 1894; West Fork White river at Gosport, Eigenmann.

Schilbeodes gyrius (Mitchill).

Wabash at Delphi, Evermann and Jenkins, 1888; Upper Blue river, Kirsch 1894; Lake Maxinkuckee, Jordan, 1889; Little Deer creek, Evermann and Jenkins, 1888; West Fork White river at Indianapolis, Jordan, 1877 as *sialis*; Bean Blossom, Eigenmann and Fordice 1885;

Big creek, Posey county, Jordan 1889; Kankakee river at Riverside, Bates 1886; Trail creek near Michigan City, Ridgley.

Schilbeodes nocturnus (Jordan and Gilbert).

Big Pigeon creek at Evansville, Jordan 1889.

Order PLECTOSPONDYLI (The Carp Fishes).

Family *Catostomidae* (The Suckers).

Ictiobus cyprinella (Cuv. and Val.) Common Buffalo Fish, Red-mouthed Buffalo.

Ohio at Louisville, Jordan and Evermann 1887; Wabash at Delphi, Evermann, 1888; at LaFayette, Jordan and Evermann; at Terre Haute, Jenkins 1886; at Mackey's Ferry, Jordan, 1889.

Ictiobus urus (Agassiz). Razor-backed Buffalo, Mongrel Buffalo.

Ohio, Jordan and Evermann 1887; Wabash at Delphi, Evermann 1888; Wabash at Terre Haute, Jenkins 1886.

Ictiobus hubalus (Rafinesque). Sucker-mouthed Buffalo, Small-mouthed Buffalo.

Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877; and at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Switz City swamp, Greene county, Gilbert 1884.

Carpionodes carpio (Rafinesque).

Lower Wabash and West Fork of White river at Indianapolis, Jordan 1877; East Fork White river near Bedford, Gilbert, 1884.

Carpionodes difformis Cope.

Big Pigeon creek at Evansville, Jordan 1889; Lower Wabash, Jordan 1877; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Eel river at Logansport, Jordan 1889; West Fork White river at Gosport, Eigenmann; East Fork White river, Salt creek, Gilbert 1884; Patoka river, Gibson county, and Big creek, Posey county, Jordan 1889.

Carpionodes velifer (Rafinesque). Quill-back, Skim-back, Carp Sucker, River Carp.

White Water river at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Kintner's creek, Wabash county, Ulrey; Eel river at Logansport, Kirsch 1894; Tippecanoe, Evermann and Jenkins 1888; West Fork White river at Gosport, Eigenmann.

Cycleptus elongatus (Le Sueur). Black Horse, Gourd-seed Sucker, Missouri Sucker.

Ohio, Jordan and Evermann 1887; White Water at Brookville, Evermann 1886; Wabash at Terre Haute, Jenkins 1886.

Catostomus catostomus (Forster). Northern Sucker, Lake Michigan, No authentic specimens from Indiana.

Catostomus commersoni Lacépède. Common Sucker, White Sucker, *Catostomus teres* of Indiana authors.

Wabash at Delphi, Evermann 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877; Eel river and its tributary streams, Round lake, Kirsch 1894; Hellem's creek, Wabash county, Ulrey; Tippecanoe river, Deer creeks, Wild Cat creek and Honey creek, Evermann and Jenkins 1888; Raccoon creek at Mecca, Parke county, I. U. Coll; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, 1884 Gilbert; Flat Rock creek at Rushville, Clifty creek, Decatur county, Shannon 1887; Little Salt creek, Franklin county, Evermann and Jenkins 1888; Clear creek, Monroe county, I. U. Coll; Yellow river at Plymouth, Jordan 1889; St. Joseph's river near Mishawaka, Jordan 1889.

Catostomus nigricans Le Sueur. Hog Sucker, Stone Roller, Stone Lugger, Stone Toter, Hammer Head, Crawl-a-Bottom, Hog Molly, Hog Mullet.

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, Jenkins 1888; Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, Jordan 1889; Eel river and its tributary streams, Kirsch 1894; Blue river at Columbia City, Jordan 1889, and Eel river at Logansport; Tippecanoe river, Deer creeks, Wild Cat creek and Honey creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Spencer, Jordan 1889; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock creek, Decatur county, Clifty creek, Decatur county, Shannon 1887; Clear creek, Monroe county, I. U. Coll.; Yellow river at Plymouth, Jordan 1889; St. Joseph's at Mishawaka, Jordan 1889.

Erimyzon sucetta oblongus (Mitchill). Chub Sucker, Sweet Sucker, Creek Fish.

Eel river and tributary streams below South Whitley, Round lake, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877; Little Deer creek and Honey creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; Pipe creek, Madison county, Shannon; Switz City swamp, Greene county, Gilbert 1884; Flat Rock creek, and Clifty creek, Decatur county, Shannon, 1887; Salt creek, Gilbert 1884; Gresham's creek at New Harmony, Jordan 1889; Maumee river, Jordan 1877; Kankakee river at Riverside, Bates 1886; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877; Trail creek, LaPorte county, Ridgley; Clear and Pine lake, LaPorte county, Jordan 1877.

Minytrema melanops (Rafinesque). Striped Sucker.

Lower Wabash, Jordan 1877; Wabash at New Harmony and Mackey's Ferry, Jordan 1889; Eel river and tributary streams, Blue and Round lakes, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork White river, Clifty creek, Decatur county, Shannon 1887; Gresham's creek at New Harmony, Jordan 1889; Yellow river at Plymouth, Jordan 1889.

Moxostoma anisurum (Rafinesque). White Nose Sucker.

Lower Wabash, Jordan 1877; Kentner's creek, Wabash county, Ulrey; East Fork White river, Gilbert 1884, as *M. velatum*.

*Moxostoma aureolum** (Le Sueur). Common Red Horse, White Sucker, Mullett.

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; Wabash at Terre Haute, Jenkins 1886; Wabash at Vincennes and New Harmoy, Jordan 1889; Lower Wabash, Jordan 1877; Eel river at Logansport, Jordan 1889; Eel river and tributary streams, Kirsch 1894; Tippecanoe river, Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Pipe creek, Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Clear creek at Bloomington, I. U. Coll; Patoka river,

* This species has usually been recorded as *M. duquesnii*.

Gibson county, Jordan 1889; Maumee, Jordan 1877; Yellow river at Plymouth, Jordan 1889.

Moxostoma breviceps (Cope).

Ohio river, Gilbert; Deer creek near Camden, Evermann 1888; West Fork White river at Spencer, Jordan 1889.

Placopharynx duquesnii (Le Sueur).

Wabash at Delphi and Terre Haute, Evermann 1888; Lower Wabash, Jordan 1877; Tippecanoe river, Evermann 1888.

Lagochila lacera Jordan and Brayton. Hare-lip Sucker, Rabbit-mouth Sucker, Pea-lip Sucker, Cut-lips, Split-mouth.

Tippecanoe river west of Delphi, Evermann and Jenkins 1888.

Family *Cyprinidae* (The Minnows).

Compostoma anomalum (Rafinesque). Stone Lugger, Stone Roller.

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Blue river at Columbia City and Eel river at Logansport, Jordan, 1889; Eel river and tributary streams, Kirsch 1894; Tippecanoe river, Jordan 1877; Tippecanoe river, Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock creek at Rushville, and Clifty creek, Decatur county, Shannon 1887, Clear creek Monroe county, I. U. Coll.; Gresham's creek at New Harmony, Jordan 1889; Maumee river, Jordan 1877; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, at Mishawaka, Jordan 1889

Chrosomus erythrogaster Rafinesque. Red-bellied Minnow.

Weasaw creek near Denver, Ind., Kirsch 1894; Honey creek, Howard county, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom, Eigenmann and Fordice 1885; Clifty creek, Decatur county, Shannon 1887; Blue river at Knightstown, I. U. Coll.; Little Salt creek Franklin county, Evermann and Jenkins 1888; Salt creek near Bedford, Gilbert 1884; Clear creek Monroe county, I. U. Coll.

Hybognathus nuchalis Agassiz.

Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at New Har-

mony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877. as *argyritis*; Eel river at Logansport, Kirsch 1894; Wild Cat and Little Deer creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877 as *argyritis*; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; Little Salt creek Franklin county, Evermann and Jenkins 1888; Big creek Posey county, Jordan 1889.

Pimephales promelas Rafinesque.

White Water at Brookville, Evermann 1886.

Pimephales notatus (Rafinesque).

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877, and at Vincennes and New Harmony 1889; Eel river and its tributary streams and lakes except Hull and Blue lakes, Kirsch 1894, and Logansport, Jordan 1889; Tippecanoe river, Jordan 1877; Loon lake and Big lake, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins 1888; Lake-Maxinkuckee, Jenkins 1888; Raccoon creek at Mecca, Parke county, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Pipe creek, Decatur county, Shannon 1887; East Fork White river and Salt creek near Bedford, Gilbert 1884; Blue river at Knightstown, I. U. Coll.; Flat Rock creek at Rushville, Shannon 1887; Clear creek, Monroe county, I. U. Coll.; Lost river at Orangeville, I. U. Coll.; Patoka river, Gibson county, Gresham's and Big creeks, Posey county, Jordan 1889; Yellow river at Plymouth, Jordan 1889; Kankakee, Jordan 1877; St. Joseph's, Jordan 1877; at Mishawaka, Jordan 1889; Clear and Pine lakes, La Porte county, Jordan 1877.

Liola vigilax (Baird and Girard). Bull-head Minnow.

Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Gosport, Eigenmann; East Fork White river near Bedford, Gilbert 1884 as *Hypargyrus tuditanus*; Black creek at New Harmony, Jordan 1889; Big creek, Posey county, Jordan 1889.

Notropis cayuga Meek.

Round and Shriner lakes; Loon lake, Kirsch 1894.

Notropis anogenus Forbes.

Blue lake and Blue river, Whitley county, Kirsch 1894.

Notropis heterodon Cope.

Wabash at Vincennes, Jordan 1889; Round, Cedar and Shriner lakes, Whitley county, Kirsch 1894; Tippecanoe river, Jordan 1877; Loon lake, Kirsch 1894; Lake Maxinkuckee, Scovell; Switz City swamp, Greene county, Gilbert 1884; Yellow river at Plymouth, Jordan 1889; Kankakee at Riverside, Bates 1886; Trail creek, LaPorte county, Ridgley.

Notropis microstomus Rafinesque.

White Water at Brookville, Evermann 1886 as *deliciosus*; Wabash at Delphi, Evermann and Jenkins 1888 as *deliciosus*, at New Harmony, Jordan 1889; Eel river at Logansport, Jordan 1889; Eel river from South Whitley to its mouth, Kirsch 1894; Tippecanoe, Evermann and Jenkins 1888 as *deliciosus*; West Fork White river at Indianapolis, Jordan 1877 as *stramineus*; at Gosport, Eigenmann at Spencer, Jordan 1889; East Fork White river near Bedford, Gilbert 1884 as *deliciosus*; Yellow river at Plymouth, Jordan 1889; Kankakee, Jordan 1877 as *stramineus*; at Riverside, Bates 1886; St. Joseph's at Mishawaka, Jordan 1889.

Notropis boops Gilbert.

Wabash at Delphi, Evermann 1888; West Fork White river at Indianapolis, Jordan 1877 as *E. scabriceps* not of Cope; East Fork White river, Clifty and Flat Rock creeks, Decatur county, Shannon 1887; Flat Rock creek, Rush county, and Salt creek, Brown county, Gilbert 1884.

Notropis hudsonius (Clinton). Spawn-eater, Smelt.

Kankakee at Riverside, and Lake Michigan at Michigan City, Bates 1886; Clear and Pine lakes, LaPorte county, Jordan 1877 as *H. storerianus*.

Notropis whipplei Girard. Silver-Fin.

Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877 as *C. analostona*;

Kentner's creek, Wabash county, Ulrey; Eel river at Logansport, Jordan 1889; from Liberty Mills to its mouth and in all the tributaries, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877 as *C. analostona*; Deer creeks, Wild Cat creek, Evermann and Jenkins, 1888; West Fork White river at Indianapolis, Jordan 1877 as *C. analostona*; at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan, 1889; East Fork White river and Salt creek near Bedford, Gilbert 1884 as *N. analostanus*; Flat Rock creek and Clifty creek, Decatur county, Shannon 1887; Little Salt creek, Franklin county, Evermann and Jenkins, 1888; Clear creek at Bloomington, I. U. Coll.; Patoka river, Gibson county, Black river and Big creek, Posey county, Jordan 1889; Maumee, Jordan 1877 as *C. analostona*; Yellow river at Plymouth, Jordan 1889.

Notropis megalops (Rafinesque). Common Shiner, Red-Fin, Dace.

White Water at Brookville, Evermann 1886; Fourteen Mile creek, Clarke county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony, and Mackey's Ferry, Jordan 1889; Kentner's creek, Wabash county, Ulrey; Blue river at Columbia City, Jordan 1889; Eel river and all its tributary streams, Cedar lake, Round lake, Kirsch 1894; at Logansport, Jordan 1889; Tippecanoe, Jordan 1877 as *plumbeolus* *L. cornutus*; Tippecanoe river, Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins, 1888; West Fork White river at Indianapolis as *L. cornutus*, Jordan 1877; at Spencer, Jordan 1889; Pipe creek, Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan, 1889; East Fork White river and Salt creek near Bedford, Gilbert, 1884; Flat Rock creek at Rushville, and Clifty creek, Decatur county, Shannon, 1887; Blue river at Knightstown, and Clear creek at Bloomington, I. U. Coll.; Patoka river, Gibson county, Black river and Big creek, Posey county, Jordan, 1889; Maumee, Jordan 1877; Kankakee river at Riverside, Bates, 1886; Yellow river at Plymouth Jordan's 1889; St. Joseph's river at Mishawaka, Jordan, 1889; Trail creek, LaPorte county, Ridgley; Clear and Pine lakes, LaPorte county, Jordan 1877 as *L. cornutus*.

Notropis jejunus (Forbes).

Eel river at Logansport, Kirsch 1894.

Notropis ariommus (Cope).

West Fork White river at Indianapolis, Jordan 1877; Raccoon creek, at Mecca, I. U. Coll.

Notropis ardens (Cope). Red-fin.

White Water at Brookville, Evermann 1886; Laughery creek at Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Kentner's creek, Wabash county, Ulrey; Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins 1888; Raccoon creek, at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *L. diplemius*; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884 as *diplemius*; Flat Rock, at Rushville, Clifty creek, Decatur county, Shannon 1887; Blue river at Knighstown, I. U. Coll.; Little Salt creek, Franklin county, Evermann and Jenkins 1888; Lost river at Orangeville; Clear creek at Bloomington, I. U. Coll.

Notropis atherinoides (Rafinesque).

Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes and New Harmony, Jordan 1889; Lower Wabash, Jordan 1877 as *N. rubellus*; Eel river at Logansport, Jordan 1889; Tippecanoe river, Big Deer creek, Wild Cat creek, Evermann and Jenkins 1888; Raccoon creek, Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *N. rubellus*; at Gosport, Eigenmann; Pipe creek, Madison county; Flat Rock creek at Rushville, Shannon 1887; Little Salt creek, Franklin county, Evermann and Jenkins 1888; Patoka river, Gibson county, Jordan 1889.

Notropis arge (Cope).

Eel river from North Manchester to mouth and at Pawpaw, Flowers and Twelve Mile creeks, Kirsch 1894; Wild Cat creek and Deer creek, Evermann and Jenkins 1888.

Notropis dilectus (Girard).

Big Pigeon creek at Evansville, Wabash at New Harmony and Mackey's Ferry, Jordan 1889; Eel river from South Whitley to mouth, Blue river, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877 as *N. dinemus*; at Gosport, Eigenmann; Big creek and Gresham's creek, Posey county, Jordan 1889.

Notropis rubrifrons (Cope).

White Water at Brookville, Evermann 1886; Fourteen Mile creek, Clark

county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Eel river at Logansport, Jordan 1889; Tippecanoe river, Jordan 1877; Tippecanoe river, Wild Cat creek, Deer creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; East Fork White river near Bedford, Gilbert 1884; Clifty and Flat Rock creeks, Decatur county, Shannon 1887; Clear creek Bloomington, I. U. Coll.; Yellow river at Plymouth, Jordan 1889; St. Joseph's at Mishawaka, Jordan 1889.

Ericymba buccata Cope.

Laughery creek, near Milton, Ohio county, Fourteen-mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Kentner's creek, Wabash county, Ulrey; Eel river in its lower six miles, Twelve-mile creek, Kirsch 1894; Tippecanoe river, Deer creek, Wild Cat and Honey creeks, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; at Spencer, Jordan 1889; Pipe creek, Madison county, Shannon 1887; East Fork White river and Salt creek, near Bedford, Gilbert, 1884; Flat Rock creek at Rushville; Flat Rock creek and Clifty creek, Decatur county, Shannon 1887; Blue river at Knightstown, I. U. Coll.; Little Salt creek, Franklin county, Evermann and Jenkins 1888; Clear creek at Bloomington, I. U. Coll.; Gresham's creek at New Harmony, Jordan 1889.

Rhinichthys atronasmus (Mitchill).

Kintner's creek, Wabash county, Ulrey; Little Weasaw creek near Denver, Cunningham; Honey creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877 as *obtusius*; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork near Bedford, Gilbert 1884; Clifty and Flat Rock creeks, Decatur county, Flat Rock creek at Rushville, Shannon 1887; Little Salt creek, Franklin county, Evermann and Jenkins 1888; Clear creek, Bloomington, I. U. Coll.; Kankakee river, Jordan 1877.

Hybopsis dissimilis (Kirtland).

Wabash at Delphi, Evermann and Jenkins 1888; at Vincennes and New Harmony, Jordan 1889; Tippecanoe river, Evermann and Jenkins 1888; West Fork White river, at Indianapolis, Jordan 1877; at Gosport, Eigenmann; at Spencer, Jordan 1889.

Hybopsis amblops (Rafinesque).

Wabash at Delphi, Evermann and Jenkins 1888; Kentner's creek, Wabash county, Ulrey; Eel river at Logansport, Jordan 1889; lower course of Eel river and tributaries; Cedar and Shriner lakes, Kirsch 1894; Tippecanoe river and Deer and Wild Cat creeks, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Pipe creek, Madison county, Shannon 1887; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork and Salt creek near Bedford, Gilbert 1884; Flat Rock, Decatur county, Shannon; Trail creek, La Porte county, Ridgley.

Hybopsis storerianus (Kirtland).

Wabash at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Eel river at Logansport, Kirsch 1894; West Fork White river at Gosport, Eigenmann; at Spencer; Big Creek Posey county, Jordan 1889.

Hybopsis watanga Jordan and Evermann.

Wabash at Terre Haute, Jenkins 1886; Eel river at Logansport, Kirsch 1894; Tippecanoe river, Jordan 1889.

Hybopsis kentuckiensis (Rafinesque). Horny Head, River Chub, Jerker.

White Water river at Brookville, Evermann 1886; Wabash river at Delphi, Evermann and Jenkins 1888; Kentner's creek, Wabash county, Ulrey; Blue river at Columbia City and Eel river at Logansport, Jordan 1889; whole of Eel river, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877 as *N. biguttatus*; Tippecanoe river, Deer creeks, Wild Cat and Honey creeks, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877 as *N. biguttatus*; at Spencer, Jordan 1889; Pipe creek Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; East Fork White river near Bedford, Gilbert 1884 as *N. biguttatus*; Flat Rock at Rushville, Flat Rock creek and Clifty creek Decatur county, Shannon 1887; Maumee river; Kankakee river, Jordan 1877 as *N. biguttatus*; Yellow river at Plymouth, Jordan 1889; St. Joseph's river at Mishawaka, Jordan 1889 and 1877 as *N. biguttatus*; Lake Michigan at Michigan City, Bates 1886; Clear and Pine lakes, Jordan 1877 as *N. biguttatus*.

Hybopsis hyostomus Gilbert.

Wabash at Delphi, Evermann and Jenkins 1888; at Vincennes and New Harmony, Jordan 1889; Eel river at Logansport, Kirsch 1894; West

Fork White river at Gosport, Eigenmann; East Fork White river near Bedford, Gilbert 1884.

Semotilus atromaculatus (Mitchill). Horned Dace, Creek Chub.

Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Kentner's creek, Wabash county, Ulrey; Eel river and its tributaries, Kirsch 1894; Tippecanoe river, Jordan 1877 as *S. corporalis*; Deer creeks and Honey creek, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *S. corporalis*; Bean Blossom creek, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; East Fork White river near Bedford, Gilbert 1884; Flat Rock creek Rushville and Clifty creek Decatur county, Shannon 1887; Blue river at Knightstown, I. U. Coll.; Little Salt creek Franklin county, Evermann and Jenkins 1888; Clear creek at Bloomington, I. U. Coll.; Gresham's creek at New Harmony, Jordan 1889; Maumee, Jordan 1877 as *corporalis*; Kankakee river, Jordan 1877 as *S. corporalis*; St. Joseph's, Jordan 1877 as *S. corporalis*; St. Joseph's river at Mishawaka, Jordan 1889; Trail creek, LaPorte county, Ridgley.

Phoxinus elongatus Kirtland.

Penn. to Minn. No authentic specimens from Indiana.

Opsopoeodus emiliae Hay.

Wabash at New Harmony and Mackey's Ferry and Big Creek and Cypress swamp, Posey county, Jordan 1889.

Notemigonus chrysolaucus (Mitchill.)

White Water at Brookville, Evermann 1886; Wabash at Terre Haute, Jenkins 1886; at New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877 as *N. americanus*; Hellem's creek, Wabash county, Ulrey; Blue river, Blue lake; Eel river, Blue Babe and Mud creeks, Kirsch 1894; Tippecanoe river, Jordan 1877 as *N. americanus*; Deer creek, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *N. americanus*; Pipe creek, Decatur county, Shannon 1887; East Fork White River, near Bedford, Gilbert 1884; Flat Rock creek at Rushville, Shannon 1887; Gresham's and Big creeks, Posey county, Jordan 1889; Maumee, Jordan 1877 as *N. americanus*; Kankakee river,

Jordan 1877 as *N. americanus*: at Riverside, Bates 1886; Clear and Pine lakes, La Porte county, Jordan as *N. americanus*.

Order ISOSPONDYLI (The Salmon Herring &c.).

Family *Hiodontidae* (The Moon-eyes).

Hiodon alosoides (Rafinesque).

Wabash at Terre Haute, Jenkins 1886; at New Harmony, Jordan 1889; West Fork White river at Gosport, Eigenmann.

Hiodon tergisus Le Sueur. Moon-eye, Silver Bass, Toothed Herring.

Tippecanoe river, Evermann 1888; Switz City swamp, Greene county, Gilbert 1884.

Family *Clupeidae* (The Herrings).

Clupea chrysochloris Rafinesque. Skip-jack.

Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Mackey's Ferry, Jordan 1889.

Dorosoma cepedianum (Le Sueur). Gizzard Shad, Hickory Shad, Mud Shad, White-eyed Shad, Hairy-back.

Laughery creek near Milton, Ohio county, Jenkins 1888, and Fourteen Mile creek, Clark county; Blue river Wyandotte Cave, I. U. Coll.; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877; Eel river at Logansport, Kirsch 1894; West Fork White river at Gosport, Eigenmann; Patoka river, Gibson county, Jordan, 1889.

Family *Salmonidae* (The White Fishes and Trout).

Coregonus quadrilateralis Richardson. Round-fish, Pilot-fish, Shad-waiter, Menomonee White-fish.

Lake Michigan, Jordan and Evermann 1887.

Coregonus clupeiformis (Mitchill). Common White-fish.

Lake Michigan, Jordan and Evermann 1887.

Coregonus labradoricus Richardson. Sault White-fish, Musquaw river White fish, "Whiting."

Lake Michigan, Jordan and Evermann 1887.

Coregonus hoyi (Gill). Lake Moon-eye, Cisco of Lake Michigan.

Lake Michigan, Jordan and Evermann 1887.

Coregonus artedii Le Sueur. Lake Herring, Cisco Michigan Herring.

Lake Michigan, Jordan and Evermann 1887.

Coregonus artedii sisco Jordan.

Shriner and Cedar lakes, Whitley county, Kirsch 1894; Eagle lake, Kos-

ciusko county, and Lake Maxinkuckee, Jordan 1877; Tippecanoe river, Jordan 1877; Crooked and Big lake, Kirsch 1894.

Salvelinus namaycush (Walbaum). Great Lake Trout, Mackinaw Trout, Salmon Trout. Longe, Togue.

Lake Michigan, Jordan and Evermann 1887.

Family *Percopsidae* (The Trout Perches).

Percopsis guttatus Agassiz. Trout Perch.

Ohio river; Lake Michigan.

Order HAPLOMI (The Pike-like Fishes).

Family *Amblyopsidae* (The Cave Fishes).

• *Amblyopsis spelaeus* (De Kay). Blind Fish of the Mammoth Cave, Indiana. Jordan.

Typhlichthys subterraneus (Girard).

Corydon, I. U. Coll.

Family *Cyprinodontidae* (The Killi-fishes).

Fundulus diaphanus menona (Jordan and Copeland).

Lake Maxinkuckee, Jenkins 1888; Clear and Pine lakes, La Porte county, and St. Joseph's river, Jordan 1877.

Zygonectes notatus (Rafinesque). Top Minnow.

Fourteen-mile creek, Clark county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Cypress swamp, Posey county, Jordan 1889; Wabash, at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877; Eel river and its tributary streams, Blue, Shriner, Cedar lakes; Loon, Big lakes, Kirsch 1894; Wild Cat and Deer creeks, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; Clifty creek, Decatur county, Shannon, 1887; Clear creek, Monroe county, I. U. Coll.; Patoka river, Gibson county, Black river, Gresham's creek and Big creek, Posey county, Jordan 1889; Maumee river, Jordan 1877; Kankakee river at Riverside, Bates 1886; St. Joseph's river, Jordan 1877.

Zygonectes dispar Agassiz.

Cypress swamp, Posey county, Jordan 1889; Wabash at Vincennes and Mackey's Ferry, Jordan 1889; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877; Lake Maxinkuckee, Jordan 1889; Switz City swamp, Greene county, Gilbert 1884; St. Joseph's river, Jordan 1877.

Gambusia patrucelis (Baird and Girard). Top Minnow.

Mackey's Ferry, Black river and Gresham's creek, Posey county, Jordan 1889.

Family *Umbrela* (The Mud-minnows).

Umbra limi (Kirkland). Mud-minnow, Dog-fish.

Wabash at Terre Haute, Jenkins 1886; Blue river at Columbia City, Jordan 1889; Eel river, upper course, Thorn and Blue Babe creeks, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877; Little and Big Deer creeks and Honey creek, Evermann 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; Salt creek near Bedford, Gilbert 1884; Maumee, Jordan 1877; Kankakee at Riverside, Bates 1886; St. Joseph's river, Jordan 1877; Clear and Pine lakes, LaPorte county, Jordan 1877.

Family *Luciida* (The Pikes).

Lucius cerniculatus (Le Sueur). Little Pickerel.

Ohio river; Wabash at New Harmony, Le Sueur; Wabash valley, Cuv. and Val. 1846; Lower Wabash, Jordan 1877 as *E. salmoneus*; Wabash at Terre Haute, Jenkins 1886; Blue river at Columbia City, Jordan 1889; Eel river and all its tributary streams and lakes, Kirsch 1894; Tippecanoe river, Jordan 1877 as *E. salmoneus*; Lake Maxinkuckee and Loon and Big lakes, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; Raccoon creek Mecca at I. U. Coll.; West Fork Whiteriver at Indianapolis, Jordan 1877 as *E. salmoneus*; Pipe creek, Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; Switz Cityswamp, Greene county, Gilbert 1884; East Fork White river at Bedford, and Salt creek, Gilbert 1884; Maumee river, Jordan 1877 as *E. salmoneus*; Kankakee at Riverside, Bates 1886; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877 as *E. salmoneus*; Trail creek, La Porte county, Ridgley; Clear and Pine lakes, La Porte county, Jordan 1877 as *E. salmoneus*.

Lucius lucius (L). Pike, Northern Pickerel.

Wabash at New Harmony, Le Sueur as *Eso. de profundis*; Eel river, Stoney Creek, Kirsch 1894; Paw Paw creek, Wabash county, Ulrey; St. Joseph's river, Jordan 1877.

Lucius masquinongy (Mitchill). Muskallunge, Maskinongy.

Ohio river, Meek and Newland, 1885; Lake Michigan, Jordan 1877; English lake.

Order APODES (The Eels).

Family *Anguillidae* (The True Eels.)

Anguilla anguilla rostrata Le Sueur. Eel.

White Water river at Brookville, Evermann 1886; Wabash at Delphi, Evermann 1888; at Terre Haute, Jenkins 1886; Eel river at Collamer as *A. chrysypa*, Kirsch 1894; Wild Cat and Deer creeks, Evermann 1888; Flat Rock and Sand creeks, Decatur county, Shannon 1887.

Order HEMIBRANCHII (The Half-gilled Fishes).

Family *Gasterosteidae* (The Sticklebacks).

Pygosteus pungitius (L.) Nine-spined Stickleback.

Lake Michigan.

Eucalia inconstans (Kirtland). Brook Stickleback.

Kentner's creek, Wabash county, Ulrey; Ponds tributary to Flat Rock and Clifty creeks Decatur county, Shannon 1887.

Order PERCISOSES.

Family *Atherinidae* (The Silversides).

Labidesthes sicculus Cope. Brook Silverside.

Wabash river at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877; at New Harmony and Mackey's Ferry Posey county, Jordan 1889; Eel river and all tributaries, Kirsch 1894; at Logansport, Jordan 1889; Tippecanoe river, Jordan 1877; Lake Maxinkuckee, Jenkins 1888; Loon lake, Kirsch 1894, Lake Manitou, Eigenmann and Norman; Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; East Fork and Salt creek near Bedford, Gilbert 1884; Flat Rock creek Decatur county, Shannon 1887; Patoka river, Gibson county, Jordan 1889; Maumee river, Jordan 1877; Clear and Pine lakes, La Porte county, Jordan 1877.

Order ACANTHOPTERI (The Spiny-rayed Fishes).

Family *Aphredoderidae* (The Pirate Perches).

Aphredoderus sayanus (Gilliams). Pirate Perch.

Wabash river at New Harmony, Blue river at Columbia City, Jordan 1889; Upper course of Eel river, Thorn creek, Kirsch 1894; Raccoon creek, at Mecca, I. U. Coll.; Pipe creek, Decatur county, Shannon 1887; Bean

Blossom, Eigenmann and Fordice 1885; Salt creek near Bedford, Gilbert 1884; Big Creek, Posey county, Jordan 1889; Maumee, Jordan 1877 as *A. cookianus*; Kankakee river at Riverside, Bates 1886; Yellow river at Plymouth, Jordan 1889.

Family *Centrarchidæ* (The Sun-fishes).

Centrarchus macropterus (Lacépède).

North Carolina to Illinois. No authentic specimens from Indiana.

Pomoxis sparoides (Lacépède). Calico Bass, Grass Bass, Bar-fish, Strawberry Bass.

Fourteen-mile creek, Clark county, Jenkins 1888; Cypress swamp at Mount Vernon, Posey county, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes and New Harmony, Jordan 1889; Eel river basin in all waters, Kirsch 1894; Tippecanoe river, Jordan 1887, as *hexacanthus*; Lake Manitou, Eigenmann and Norman; Lake Maxinkuckee, Jordan 1889; Crooked lake, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877, as *hexacanthus*; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; Switz City swamp, Greene county, Gilbert 1884; Clifty creek, Decatur county, Shannon 1887; Patoka river, Gibson county, Jordan 1889.

Pomoxis annularis Rafinesque. Crappie, Bachelor, New Light, Campbellite, Sac-a-lai.

Falls of the Ohio, Rafinesque 1818; White Water at Brookville, Evermann 1886; Fourteen Mile creek, Clark county, Jenkins 1888; Big Pigeon at Evansville, Jordan, 1889; Wabash at Terre Haute, Jenkins 1886; at New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877; Eel river, Blue river, Meredith creek, Kirsch, 1894; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; Salt creek, Bedford, Gilbert 1884

Ambloplites rupestris (Rafinesque). Rock Bass, Red Eye, Goggle Eye.

White Water river at Brookville, Evermann 1886; Fourteen Mile creek, Clarke county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877; Blue river at Columbia City, Jordan 1889; Eel river and tributary streams, Kirsch 1894; Eel river at Logansport, Jordan 1889; Tippecanoe river, Jordan 1877; Tippecanoe river, Evermann and Jenkins 1888; Wild Cat and Deer creeks; Lake Maxinkuckee, Jenkins 1888;

West Fork White river at Indianapolis, Jordan 1877; Pipe creek, Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river at Bedford and Salt creek, Gilbert 1884; Flat Rock at Rushville; Flat Rock and Clifty creeks, Madison county, Shannon 1887; Yellow river at Plymouth, Jordan 1889; St. Joseph's, Jordan, 1877; at Mishawaka, Jordan 1889; Trail creek, LaPorte county, Ridgley.

Chaenobryttus gulosus (Cuv. and Val.) War Mouth. Red eyed Bream.

Cypress swamp, Posey county and Wabash at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan, 1877; Eel river and tributaries; Loon and Big lakes, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877; Switz City swamp, Greene county, Gilbert 1884; Yellow river at Plymouth, Jordan 1889; Clear and Pine lakes, LaPorte county, Jordan 1877; Trail Creek and LaPorte county, Ridgley.

Lepomis cyanellus (Rafinesque). Green Sun-fish.

Ohio, Rafinesque; White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, Jenkins 1888, and Fourteen Mile creek, Clark county; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, Jordan 1889; Eel river and all its large tributary streams and lakes, Kirsch 1894; Tippecanoe river, Deer creeks and Wild Cat Creek, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; Pipe creek, Madison county, Shannon 1887; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock creek at Rushville, and Clifty creek, Madison county, Shannon 1887; Lost river at Orangeville; Clear creek, Monroe county, I. U. Coll.; Gresham's creek at New Harmony, Jordan 1889; Kankakee river, Jordan 1877; Clear and Pine lakes, LaPorte county, Jordan 1877.

Lepomis macrochirus Rafinesque.

West Fork White river at Indianapolis, Jordan 1877.

Lepomis humilis (Girard).

Big creek at New Harmony, Jordan 1889.

Lepomis pallidus (Mitchill). Blue Sun-fish, Copper-nosed Bream, Dollardee.

Wabash at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877 as *L. incis-*

or; Eel river and all its tributaries, Kirsch 1894; Tippecanoe river, Jordan 1877 as *L. incisor*; Lake Manitou, Eigenmann and Norman; Lake Maxinkuckee, Jenkins 1888; Loon, Big and Crooked lakes, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877 as *L. incisor*; at Gosport, Eigenmann; Switz City Swamp, Greene county, Gilbert 1884; Maumee, Jordan 1877 as *L. incisor*; St. Joseph's, Jordan 1877 as *L. incisor*; Clear and Pine lakes, LaPorte county, Jordan 1877 as *L. incisor*. Trail creek, LaPorte county, Ridgley.

Lepomis megalotis (Rafinesque).

Ohio river, Rafinesque; White Water at Brookville, Evermann, 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins, 1888; Wabash at Delphi, Evermann and Jenkins, 1888; at Terre Haute, Jenkins, 1886; at New Harmony and Mackey's Ferry, Jordan, 1889; Kentner's creek, Wabash county, Ulrey; Eel river and its tributary streams, Hull lake, Kirsch, 1894; at Logansport, Jordan, 1889; Tippecanoe, Deer creeks and Wild Cat creek, Evermann and Jenkins, 1888; Lake Maxinkuckee, Jenkins, 1888; Loon lake, Kirsch 1894; West Fork White river, at Indianapolis, Jordan, 1877, as *L. peltastes*; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice, 1885; East Fork White river and Salt creek near Bedford, Gilbert, 1884; Clifty creek, Decatur county, Shannon, 1887; Clear creek, Monroe county, I. U. Coll.; Patoka river, Gibson county, Jordan, 1889; Kankakee river, Jordan, 1877, as *L. peltastes*; Yellow river, at Plymouth, Jordan, 1889; St. Joseph's at Mishawaka, Jordan 1889.

Lepomis garmani Forbes.

Mackey's Ferry, Jordan 1889.

Lepomis eurycorpus McKay.

Cedar and Shriner lakes and upper Eel river, Whitley county, Kirsch 1894.

Lepomis heros (B. and G.) McKay.

Round lake, Whitley county, Kirsch 1894; Lake Manitou, Eigenmann and Norman.

Lepomis notatus (Agass.) McKay.

Mackey's Ferry, Jordan 1889.

Lepomis gibbosus (L). Common Sun-fish, Bream, Pond-fish, Pumpkin-seed, Sunny.

Wabash at Terre Haute, Jenkins 1886; Eel river at South Whitley,

Cedar, Shriner, Round, Hull and Wilson lakes, Kirsch 1894; Paw Paw creek, Wabash county, Ulrey; Tippecanoe river, Jordan 1877; Loon lake, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Lake Maxinkuckee, Jordan 1889; Maumee, Jordan 1877; Kankakee, Jordan 1877; at River side, Bates 1886; St. Joseph's, Jordan 1877; at Mishawaka, Jordan 1889; Clear and Pine lakes, Laporte county, Jordan 1877.

Micropterus dolomieu (Lacépède). Small-mouthed Black Bass.

White Water at Brookville, Evermann 1886; Laughery creek, near Milton, Ohio county, Jenkins 1888; Fourteen-mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877, as *floridanus*; Eel river at Logansport, Jordan 1889; Eel river and all tributaries, Kirsch 1894; Tippecanoe river, Jordan 1877, as *floridanus*; Tippecanoe river, Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; West Fork White river, at Indianapolis, Jordan 1877, as *floridanus*; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; Eel river, at Cataract, Owen county, Jordan 1889; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Blue river, at Knightstown, Clear creek, Monroe county, I. U. Coll.; Maumee river, Jordan 1877, as *floridanus*; Kankakee river, Jordan 1877, as *floridanus*; Yellow river, at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877, as *floridanus*; at Mishawaka, Jordan 1889; Clear and Pine lakes, La Porte county, Jordan 1877, as *floridanus*.

Micropterus salmoides (Lacépède). Large mouthed Black Bass, Green Bass, Oswego Bass, Bayou Bass.

White Water river, at Brookville, Evermann 1886; Fourteen-mile creek, Clark county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Dephi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877; Blue river at Columbia City, Jordan 1889; Eel river and large tributaries, and all the lakes, Kirsch 1894; Tippecanoe river, Jordan 1877; Tippecanoe river, Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; Lake Manitou, Eigenmann and Norman; Lake Maxinkuckee, Jenkins 1888; Loon, Big and Crooked lakes, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Switz City swamp,

Greene county, Gilbert 1884; East Fork White river and Salt creek, near Bedford, Gilbert 1884; Patoka river, Gibson county, and Black river, Posey county, Jordan 1889; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877; Trail creek, La Porte county, Ridgley.

Family *Percidae* (The Perches).

Etheostoma pellucidum Baird. Sand Darter.

Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at New Harmony and Mackey's Ferry, Jordan 1889; Eel river from Collamer to Logansport, Kirsch 1894; at Logansport, Jordan 1889; Tippecanoe river, Wild Cat and Deer creeks, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White River at Indianapolis, Jordan 1877; at Gosport, Eigenmann; Bean Blossom, Eigenmann and Fordice 1885; East Fork near Bedford, Gilbert 1884.

Etheostoma asprellus (Jordan).

Rising Sun, Ohio county, Jenkins 1888; Wabash at Vincennes and New Harmony, Jordan 1889.

Etheostoma nigrum Rafinesque. "Johnny."

White Water river at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile Creek, Clark county, Jenkins 1888; Wabash river at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Kentner's creek, Wabash county, Ulrey; Blue river at Columbia City, Jordan 1889; Eel river at Logansport and tributary streams, Cedar and Round lakes, Kirsch 1894; Tippecanoe river, Wild Cat and Honey creeks and Deer creeks, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; Raccoon creek at Mecca, Parke county, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *Boleostoma maculatum*; at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom creek, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884 as *B. maculatum*; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Blue river at Knightstown; Lost river at Orangeville; Clear creek, Monroe county, I. U. Coll.; Patoka river Gibson county, Black river, Gresham's and Big creeks, Posey county, Jordan 1889; Kankakee river at Riverside, Bates 1886; Yellow river at Plymouth, Jordan 1889; St. Joseph's at Mishawaka, Jordan 1889; Trail

creek, LaPorte county, Ridgley.

Etheostoma chlorosoma (Hay).

Cypress swamp, Posey county, Wabash at New Harmony and Mackey's Ferry and Big creek, Posey county, Jordan 1889.

Etheostoma blennioides Rafinesque. Green-sided Darter.

White Water river at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash river at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Lower Wabash, Jordan 1877; Blue river at Columbia City, Jordan 1889; Eel river at Logansport, Jordan 1889; Eel river and its tributary streams, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Deer creeks, Wild Cat creek, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Blue river at Knightstown, I. U. Coll.

Etheostoma coplandi (Jordan).

Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes and New Harmony, Jordan 1889; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann.

Etheostoma histrio Jordan and Gilbert.

Patoka river, Gibson county, Jordan 1889.

Etheostoma shumardi (Girard).

Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Hutsonville, Ill., Vincennes and New Harmony, Jordan, 1889; Lower Wabash, Jordan 1877; West Fork White river at Indianapolis, Jordan 1877.

Etheostoma uranidea (Jordan and Gilbert).

Wabash at Vincennes and New Harmony, Jordan 1889.

Etheostoma caprodes Rafinesque. Log Perch, Hog-fish, Crawl-a-bottom.

White Water river at Brookville, Evermann 1886; Fourteen Mile creek Clark county, Jenkins 1888; Wabash river at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes, New Harmony and Mackey's Ferry, Jordan 1889; Lower Wabash, Jordan 1877; Lower course of Eel river, Pawpaw creek, Flowers, Twelve Mile creeks, Kirsch 1894; Eel at Logansport, Jordan 1889; Tippecanoe river, Wild

Cat and Deer creeks, Evermann and Jenkins 1888; Loon lake, Kirsch 1894; Raccoon creek at Mecca, I. U. Coll., West Fork White river at Indianapolis, Jordan 1877; at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; Clifty and Flat Rock creeks, Decatur county, and Flat Rock river at Rushville, Shannon 1887; Salt creek near Bedford, Gilbert 1884; Patoka river, Gibson county, and Big creek Posey county, Jordan 1889; St. Joseph's river, Jordan 1877.

Etheostoma macrocephalum Cope.

Ohio valley. No authentic specimens from Indiana.

Etheostoma ouachita (Jordan and Gilbert).

Patoka river, Gibson county, Jordan 1889.

Etheostoma aspro (Cope and Jordan).

White Water river at Brookville, Evermann 1886; Wabash at Delphi, Evermann and Jenkins, 1888; at Terre Haute, Jenkins 1886; at New Harmony, Jordan 1889; Blue river at Columbia City, Jordan 1889; Eel river at Logansport, Jordan 1889; Eel river and all its tributary streams. Kirsch 1894; Tippecanoe river, Deer creeks and Wild Cat creek, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock and Sand creeks, Decatur county, Shannon 1887; Big creek, Posey county, Jordan, 1889; Kankakee at Riverside, Bates 1886; Yellow river at Plymouth, Jordan 1889; St. Joseph's at Mishawaka, Jordan 1889.

Etheostoma phoxocephalum Nelson.

Blue river at Wyandotte Cave, I. U. Coll.; Wabash river at Delphi, Evermann and Jenkins 1888; at Terre Haute, Evermann 1888; at Vincennes and New Harmony, Jordan 1889; Lower Wabash, Jordan 1877; Eel river at Logansport, Jordan 1889; West Fork White river at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; East Fork and Salt creek near Bedford, Gilbert 1884; Patoka river, Gibson county and Big creek, Posey county, Jordan 1889.

Etheostoma scierum (Swain).

Wabash at Vincennes and New Harmony, Jordan, 1889; Tippecanoe river, Jenkins 1888; West Fork White river at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom, Monroe county, Swain; Salt

creek near Bedford, Gilbert 1884; Patoka river, Gibson county, Jordan 1889.

Etheostoma evides (Jordan and Copeland).

Wabash river at Delphi, Evermann and Jenkins 1888; at Vincennes and New Harmony, Jordan 1889; Lower Wabash, Jordan 1877; Eel river at Logansport, Jordan 1889; Tippecanoe river, Evermann and Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877; at Gosport, Gilbert and Swain; St. Joseph's river, Jordan 1877.

Etheostoma variatum Kirtland.

White Water at Brookville, Jordan 1885, Evermann 1886.

Etheostoma zonale (Cope).

White Water at Brookville, Evermann 1886; Blue river at Wyandotte Cave, I. U. Coll.; Yellow river at Plymouth, Jordan 1889.

Etheostoma caeruleum (Cope). Blue-breasted Darter.

Eel River, between South Whitley and North Manchester, Kirsch, 1894; Tippecanoe river, Jenkins 1888; West Fork White river at Indianapolis, Jordan 1877.

Etheostoma maculatum Kirtland.

Tippecanoe river, Jordan 1877; Deer creek, Jordan 1889; West Fork White river at Indianapolis, Jordan 1877; Maumee river Jordan 1877; Kankakee river, Jordan 1877; Yellow river at Plymouth, Jordan 1889; St. Joseph's river, Jordan 1877.

Etheostoma flabellare Rafinesque.

White Water at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, Jenkins 1888; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; Blue river at Columbia City, Jordan 1889; Eel river between South Whitley and North Manchester, Kirsch 1894; Tippecanoe river, Wild Cat creek and Deer creeks, Evermann and Jenkins 1888; Raccoon creek at Mecca, I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877; Bean Blossom, Eigenmann and Fordice 1885; Eel river at Cataract, Owen county, Jordan 1889; Salt creek near Bedford, Gilbert 1884; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Clear creek, Monroe county, I. U. Coll.

Etheostoma squamiceps Jordan.

Gresham's creek and Big creek, Posey county, Jordan 1889.

Etheostoma tippecanoe Jordan and Evermann.

Tippecanoe river, Jordan 1889.

Etheostoma caeruleum Storer. Rainbow Darter, Soldier-fish.

White Water river at Brookville, Evermann 1886; Laughery creek near Milton, Ohio county, and Fourteen Mile creek, Clark county, Jenkins 1888; Wabash at Delphi, Evermann and Jenkins 1888; at Terre Haute, Jenkins 1886; at Vincennes and New Harmony, Jordan 1889; Kentner's creek, Wabash county, Ulrey; Blue river at Columbia City, Jordan 1889; Eel river and tributary streams, Kirsch 1894; at Logansport, Jordan, 1889; Tippecanoe river, Wild Cat creek, Deer creeks, Evermann and Jenkins 1888; Lake Maxinkuckee, Jenkins 1888; Raccoon creek at Mecca I. U. Coll.; West Fork White river at Indianapolis, Jordan 1877 as *Pacilichthys variatus*; at Gosport, Eigenmann; at Spencer, Jordan 1889; Bean Blossom, Eigenmann and Fordice 1885; East Fork White river and Salt creek near Bedford, Gilbert 1884; Flat Rock and Clifty creeks, Decatur county, Shannon 1887; Blue river at Knightstown, Clear creek, Monroe county, I. U. Coll.; Yellow river at Plymouth, Jordan 1889; St. Joseph's at Mishawaka, Jordan 1889.

Etheostoma caeruleum spectabile Agassiz.

Lakes drained by Eel river, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877; Kankakee river, Jordan 1877; St. Joseph's river, Jordan 1877.

Etheostoma jessie (Jordan and Brayton).

Wabash at Delphi, Evermann and Jenkins 1888; at Vincennes and New Harmony, Jordan 1889; Big Creek, Posey county, Jordan 1889.

Etheostoma fusiforme (Girard).

Cypress swamp, Posey county, Jordan 1889; Wabash at Terre Haute and New Harmony, Jordan 1889; Switz City swamp, Greene county, (Gilbert 1884 as *B. palustris*; Big creek, Posey county, Jordan 1889).

Etheostoma eos (Jordan and Copeland).

Wabash at Terre Haute, Jenkins 1886; Blue, Cedar, Round and Shriner lakes, Whitley county, Kirsch 1894; Tippecanoe river, Jordan 1877; Lake Maxinkuckee, Jenkins 1888; Maumee river and St. Joseph's river, Jordan 1877; Clear and Pine lakes, La Porte county, Jordan 1877.

Etheostoma microperca Jordan and Gilbert. Least Darter.

Blue lake, Round lake, Kirsch 1894; West Fork White river at Indianapolis, Jordan 1877 as *M. punctulata*; Maumee river, Jordan 1877; Kankakee river at Riverside, Bates 1886; St. Joseph's river, Jordan 1877; Clear and Pine lakes, La Porte county, Jordan 1877.

Perca flavescens (Mitchill). Yellow Perch, Ringed Perch.

Upper courses of Eel river and Blue river, lakes drained by Blue river, Kirsch 1894; Wabash at Terre Haute, Jenkins 1886; Lake Manitou, Eigenmann and Norman; Tippecanoe river, Jordan 1877; Lake Maxinkuckee, Jenkins 1888; Loon, Big, Crooked lakes, Kirsch 1894; St. Joseph's river, Turkey lake, Jordan 1877; Lake Michigan at Michigan City, Bates 1886; Clear and Pine lakes, La Porte county, Jordan 1877.

Stizostedion vitreum (Mitchill). Wall-eye, Glass-eye, Pike-Perch, Jack Salmon.

Wabash at Terre Haute; Jenkins 1886.

Stizostedion canadense (C. H. Smith). Sauger, Sand Pike, Gray Pike, Hornfish.

White Water at Brookville, Evermann 1886; Wabash at Terre Haute, Jenkins 1886.

Family *Serranidae* (The Sea Bass).

Roccus lineatus (Bloch). Striped Bass, Rock-fish, Rock.

No authentic Indiana specimens.

Roccus chrysops (Rafinesque). White Bass.

No authentic Indiana specimens.

Morone interrupta (Gill). Yellow Bass.

Wabash, at Terre Haute, Jenkins 1886.

Family *Sciaenidae* (The Drums).

Aplodinotus grunniens (Rafinesque). Fresh Water Drum, Gaspergou, "Sheep's-head," White Perch, Croaker, Thunder pumper.

Ohio river; White Water, at Brookville, Evermann 1886; Big Pigeon creek at Evansville, Jordan 1889; Wabash at Terre Haute, Jenkins 1886; at New Harmony and Mackey's Ferry, Jordan 1889; West Fork White river at Indianapolis, Jordan 1877; Patoka river, Gibson county, Jordan 1889.

Family *Cottidae* (The Sculpins).

Cottus ricei (Nelson).

Lake Michigan. No authentic Indiana specimens.

Cottus bairdi (Girard). Miller's Thumb, Blob, Muffle-jaw.

White Water river at Brookville, Evermann 1886; Kentner's creek, Wabash county, Ulrey; Blue river at Columbia City, Jordan 1889; Eel river and large tributaries, Kirsch 1894; Lake Manitou, Eigenmann and Norman; Honey creek and Deer creeks, Evermann and Jenkins 1888. as *richardsoni*; West Fork White river, at Indianapo-

lis, Jordan 1877, as *wilsonii* and *carolina* : at Spencer, Jordan 1889; Bean Blossom creek, Eigenmann and Fordice 1885; Clifty and Flat Rock creeks, Decatur county, Flat Rock river at Rushville; Shannon 1887; Lost river at Orangeville; Yellow river at Plymouth, Jordan, 1889; Trail creek, La Porte county, Ridgley.

Cottus pollianus (J. and G.).

Lake Michigan. No authentic Indiana specimens.

Cottus hoyi (Putnam).

Lake Michigan. No authentic Indiana specimens.

Family *Gadidae* (The Cod-fishes).

Lota lota maculosa (Le Sueur). Burbot, Lawyer, Ling.

New Albany, Jordan 1888.

Summary of Families of Fishes found in Indiana, with their numbers of genera and species:

	No. of Genera.	No. of Species.
1 Petromyzontidae	2	2
2 Polyodontidae	1	1
3 Acipenseridae	2	2
4 Lepisosteidae	1	3
5 Amiidae	1	1
6 Siluridae	5	14
7 Catostomidae	8	17
8 Cyprinidae	13	33
9 Hiodontidae	1	2
10 Clupeidae	2	2
11 Salmonidae	2	7
12 Percopsidae	1	1
13 Amblyopsidae	2	2
14 Cyprinodontidae	3	4
15 Umbridae	1	1
16 Luciidae	1	3
17 Anguillidae	1	1
18 Gasterosteidae	2	2
19 Atherinidae	1	1
20 Aphredoderidae	1	1
21 Centrarchidae	6	17
22 Percidae	3	32
23 Serranidae	2	3
24 Sciaenidae	1	1
25 Cottidae	1	4
26 Gadidae	1	1
	65	158

Not more than one-third of these have been found at any one locality.

The largest number recorded from any one locality is the forty-two species enumerated for Bean Blossom creek in about one mile of its course.

Over half of the genera (34), and more than two-thirds of the species belong to the following five families: Siluridæ, Catostomidæ, Cyprinidæ, Centrarchidæ, Etheostomidæ. About one fifth of the species are minnows, another fifth are darters, cat-fish and suckers together form a third fifth, the sunfishes, salmon and trout, and Cyprinodontidæ complete the fourth fifth and the last fifth is made up of nineteen other families.

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BY A. W. BUTLER.

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1876. **Haymond, R.** Notes on the Bank Swallow, (*i. e.*, *Stelgidopteryx serripennis*). *Field and Forest*, vol. I, 1876, No. 11, p. 88.

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NOTES ON INDIANA BIRDS.

BY A. W. BUTLER.

The following observations are supplementary to the paper on the Birds of Indiana published in the Transactions of the Indiana Horticultural Society 1890:

Ammodramus lecontei (Aud.). Le Conte's Sparrow.

Mr. J. E. Beesley took a specimen of this species from a flock of three or four sparrows, possibly of the same kind at Lebanon, Ind., March 30, 1892. This is the third record for the state.

Dendroica discolor (Vieill.). Prairie Warbler.

Mr. Beesley took two or them at Lebanon, Ind., April 29, 1892. This is the fourth locality from which they have been reported in the state and the first record from the northern half. Another record however has recently come to hand. Mr. W. O. Wallace took one specimen May 2, 1892 at Wabash.

Dendroica tigrina (Gmel.). Cape May Warbler.

The spring of 1892 this species was comparatively common throughout the state. Only twice have they heretofore been reported in any numbers, and never so numerous as last year.

Ardea egretta (Gmel.). American Egret.

Rare throughout the northern part of the state. A male in full plumage was killed May 17, 1892 near Frankfort, Ind. Detailed information regarding its breeding in the state is much desired.

Pelecanus erythrorhynchos Gmel. White Pelican.

A bird of this species was killed May 25, 1892 near Bloomfield, Greene county, Ind.

Botaurus exilis (Gmel.). Least Bittern.

One specimen was taken May 10 and another May 19, 1892 near Lebanon, Ind. I am informed by Mr. J. E. Beesley that they breed in that vicinity but not abundantly. Mr. W. O. Wallace took two specimens at Wabash early in May 1892.

Clangula hyemalis (Linn.). Old Squaw.

Mr. Beesley informs me that a bird of this species was killed near Throntown, in May 1892.

Phalaropus lobatus (Linn.). Northern Phalarope.

A pair taken in Boone county, June 7, 1889 (Beesley). This is the second record for the state. The specimens and those of the next species are probably now in the state collection at Indianapolis.

Phalaropus tricolor (Vieill.). Wilson's Phalarope.

A pair of these birds taken May 9, 1889 in Boone county. This is the first record from that part of the state.

Anser albifrons gambeli. (Hartl.). American White-fronted Goose.

One was killed April 17, 1892 near Peru. (Beesley). This is its third reported occurrence in the state.

Anhinga anhinga (Linn.). Anhinga; Snake bird.

Mr. Beesley informs me that he killed a pair of these birds on what is known as the "Broad cut" of the canal just north of Indianapolis in 1858.

This is the first record from the state, but another specimen is reported to have been taken since. (Cat-birds of Ind. p. 18).

Phalacrocorax dilophus floridanus (Aud.). Florida Cormorant.

The same gentleman took a bird of this species near Indianapolis, May 8, 1858.

Tryngites subruficollis (Vieill.). Buff-breasted Sandpiper.

Messrs. C. D. and L. A. Test took this bird Sept. 10, 1892 from a large shallow pond about four miles northwest of Lafayette. This is the first reported occurrence of this bird within the state.

Micropalama himantopus (Bonap.). Stilt Sandpiper.

The same gentlemen took a specimen of this bird from the same locality Oct. 10, 1892. This is the first time it has been reported within the state. Through the kindness of the collectors this specimen, the one last mentioned and *Junco hyemalis shufeldti* have been placed in my collection.

Colymbus holboellii (Reinh.). Holboell's Grebe.

Dr. J. L. Hancock, of Chicago, reports having identified it at Wolf lake, Ind., in the spring of 1883, also at Park Side, Ill., April 29, 1883. This is the only reported record of the species in Indiana.

Larus philadelphia (Ord.). Bonaparte's Gull.

Dr. Hancock informs me this species is a summer resident in the northwestern part of the state where it frequents the large lakes in early spring and later breeds in the small inland lakes.

Sterna antillarum (Less.). Least Tern.

Found nesting at Wolf lake. Common some years ago but now rather rare. (Dr. J. L. Hancock).

Aythya marila nearctica (Stejn.). American Scaup Duck.

Identified April 9, 1887 at Hammond, by Graham Davis (Dr. Hancock).

Ampelis garrulus Linn. Bohemian Waxwing.

Dr. Hancock says: "A flock of eight of these birds were seen feeding on mountain ash berries March 1, 1880 in Chicago. I shot two specimens."

Cistothorus stellaris (Licht.). Short-billed Marsh Wren.

Noted at Hammond, Apr. 9, 1887 by Graham Davis (Dr. Hancock).

Tringa bairdii (Coues). Baird's Sandpiper.

A specimen taken Aug. 26, 1893 by W. O. Wallace at Wabash. The first Indiana record.

Nyctea nyctea (Linn.). Snowy Owl.

A specimen taken at Cedar Grove, Franklin county, December 1893. This is a rare bird in the southeastern quarter of the state.

Calcarius lapponicus (Linn.). Lapland Longspur.

Has been taken at Wabash, Ind. One specimen. (Wallace).

Dendroica kirtlandi Baird. Kirtland's Warbler.

(One specimen, Wabash, Ind., May 1, 1893 taken by W. O. Wallace. This is the first specimen of this rare warbler reported from the state. Mr. Wallace has very kindly presented me with the specimen.

The species was described from a specimen taken by Dr. Kirtland near Cleveland, O. The following are the reported records of its occurrence:

1. At sea off Abaco, Bahamas, by Dr. Samuel Cabot, second week in October, 1841.

2. Near Cleveland, O., by Dr. J. P. Kirtland, male, May 15, 1851. Type specimen.

3. Near Cleveland, O., by R. K. Winslow, female, June, 1860.

4. Near Cincinnati, O., by Charles Dury, male, first week in May, 1872.

5. Ann Arbor, Mich., by A. B. Covert, female, May 15, 1875.

6, 7. Rockport, Cuyahoga county, O., by Wm. and John Hall, May, 1878.

8. Andros Island, Bahamas, by Charles B. Cory, female, Jan. 9, 1879.

9. Ann Arbor, Mich., by A. B. Covert, female, May 16, 1879.

10, 11. Cleveland, O., reported by Dr. Langdon, male and female, May 4, 12, 1880.

12. Battle Creek, Mich., male, May 11, 1883, now in U. S. National Museum.

13. St. Louis, Mo., May 8, 1885. Otto Widmann.

14. Spectacle Reef, Mich., May 25, 1885. Wm. Marshall. Struck the light at Spectacle Reef light house.

15. Near Dublin Gap Springs, Pa., June 25., 1885. Prof. H. J. Roddy. He says: "Saw one with family."

16. St. Helena Island, S. C., Apr. 27, 1886. Walter Hoxie. Reports seeing three others.

17. Near Fort Meyer, Va., Sept. 25, 1887. Wm. Palmer. Another seen a week later.

18. Ann Arbor, Mich., Apr. or May 1888, female, by Mr. Knapp.

19. Chester, S. C., female, Oct. 11, 1888. L. M. Loomis.

20. Near Minneapolis, Minn., May 13, 1892, male. H. M. Guilford.

21. Wisconsin. Dr. P. R. Hoy. Reported seen.

22. Wabash, Ind., May 1, 1893. W. O. Wallace.

The winter home of this rare and narrowly restricted species is apparently the Bahama Islands. It has been taken most commonly during the

spring migrations near Cleveland, O. and Ann Arbor, Mich. It has never been taken in the interior of the United States during the fall migrations. The summer home of this warbler would seem to be northern Michigan and Wisconsin or north thereof and possibly in the mountains of Pennsylvania. The line of its spring movements seems to be a narrow route from the Bahamas past the western end of Lake Erie toward Lake Superior. Perhaps the return migration may be over the same route but it is possible this may be, in whole or in part, farther to the eastward passing down the coast after it reaches the Atlantic.

Its distribution is very remarkable. Yet there seems to be an effort on the part of other species to follow a line remarkably similar to that noted. From the northwest into South Carolina, even to the coast, there seems to be a migration route analagous to this. Along it would seem to move, in a southeastly migration, such forms as Brewer's Blackbird, Yellow-headed Blackbird, Leconte's Sparrow, Prairie Horned Lark, typical plains forms.

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PRELIMINARY LIST OF INDIANA MAMMALS.

1. *Didelphis virginiana* Shaw. Common Opossum.
Randolph county (Cox).
Wabash county. Specimen in Galbraith's collection.
Benton county. One sent me from there the winter of 1889-90.
Carroll county, Vigo county, Monroe county. I have seen it in all of these counties (Evermann).
Parke county. W. S. Blatchley's brother caught seven in one night the fall of 1890 near Rockville. Very plenty (M. H. Anderson). Many are brought in every winter to the market at Terre Haute.
Pike county. (Abundant), Indiana Farmer.
Howard county. Formerly abundant until the winter of 1855-6, when they were almost exterminated by severe winter. Since that time have been very scarce. One seen winter of 1885-6 (A. W. Moon).
Huntington county. Wm. E. Bardsley reports an opossum killed near Pleasant Plain the winter of 1892-3.
Hendricks county. Unusually abundant near Hadley winter of 1892-3.
Reported in Indiana Farmer, Feb. 4, 1893, (A. Hadley).
Franklin county. Have not been noticeably abundant for a number of

years, until 1892, when quite a number were reported, even coming into Brookville and killing poultry.

Miami county. Abundant until the winter of 1854 (I think it was).

Only a few have been seen since (Oliver Borden).

Porter county. Opossums are becoming numerous in this section of the state (R. B. Trouslot).

St. Joseph county. A number found winter of 1892-3 (H. H. Swain).

Dr. Jordan, in his Manual, says the first toe is without a claw. I have a specimen that has a well-developed claw on each of the first three toes (Evermann).

2. *Lepus sylvaticus* Bachman. Cotton-tail.

Abundant all over the state. Two young ones found at Brookville, January 8, 1890.

3. *Lepus campestris* Bachman.

Mr. Chas. L. Reynolds, of Frankfort, informs me that he mounted one that was taken near Chauncy, in the summer of 1888. The specimen is now in the possession of Mr. Max Spring, a stationer, of La Fayette.

In the winter of 1876-77, I was told that an unusual rabbit was caught near Prince William, in Carroll county (Evermann).

4. *Erethizon dorsatus* (L.). Canada Porcupine.

Mr. C. L. Reynolds says he saw a porcupine on the Wild Cat creek, near La Fayette, about eleven years ago. Dr. Haymond gives it in his mammals of Franklin county. Mr. E. R. Quick reports it having occurred several years since. My mother gave me a vivid account of a fight between a dog and a porcupine which she witnessed in Franklin county forty or more years ago (Butler).

La Grange county (S. D. Steininger, 1860-1870).

Huntington county. Formerly observed; none reported in past seven or eight years (W. E. Bardsley).

Grant county. In the fall of 1892 a fine specimen of the porcupine was taken near Marion (E. L. Guthrie).

Randolph county. Quite common twenty years ago, now not found (Cox).

5. *Zapus hudsonicus* (Zimm.). Jumping Mouse.

Mr. A. J. McCarthy, of Burlington, Carroll county, says in the spring of 1890 he caught three mice that had very long tails and very long hind legs, but short fore legs. They were seen by J. M. Beck also.

They are, apparently, jumping mice. Mr. A. B. Ulrey reports a specimen from Wabash county in Mr. Galbraith's collection.

La Grange county. According to S. D. Steininger.

Reported by Ernest W. Vickers from Mahoning county, Ohio.

Vigo county. Terre Haute, 1889 (W. S. Blatchley).

Stark county. Rather common, frequenting wild sod (Amos P. Atwood).

Knox county. Not uncommon, especially in the low prairie lands along the Wabash river (J. M. Risley).

Howard county. Rare. Only two seen in a lifetime (Isaac F. Street).

6. *Geomys bursarius* (Shaw). Pocket Gopher.

Mr. W. W. Archibald, of Newton county, tells that "a brown pouched gopher is found in that county, but it is not common" (Evermann).

7. *Fiber zibethicus* (L.). Muskrat.

Carroll, Monroe, Franklin and Vigo counties. It seems common in Vigo county. In the Five-mile pond, near Terre Haute, I counted 140 houses the other day, and in the Goose pond, ten miles south of Terre Haute, I have seen many houses. A trapper, near the Goose pond, told me that for several years he had caught about 160 each year at this pond (Evermann).

La Grange county (S. D. Steininger).

Wabash county (Ulrey).

Randolph county (Cox). Common.

Fayette, Fulton and Marshall counties.

The paper by one of the authors on the habits of the muskrat, published in the American Naturalist, November, 1885, gives the result of the observations of the writer in the White Water valley.

8. *Synaptomys cooperi* Baird. Lemming Mouse.

Franklin county. Identified by Dr. Haymond at Brookville thirty-five or more years ago. Its range appears to be quite restricted. It has been found on Brown's hill, southeast of Brookville, and along the bluffs for a mile and a half northwest of Brookville. From the stomach of a hawk killed in the eastern part of the county was obtained the skull of one of these mice. This mouse is considered to be quite a rare mammal. In 1878 Mr. E. R. Quick discovered its presence in numbers.

Brown county, Nashville, (Jordan).

Washtenaw county, Ann Arbor, Mich. Taken by Prof. J. B. Steere. He

informs me he does not know of its occurrence elsewhere in the state. At Ann Arbor it is confined to a very restricted locality.

9. *Arvicola pinetorum* (Le C.). Pine Mouse.

Franklin county. To Mr. Quick belongs the credit of obtaining the first reported pine mice from Indiana. In certain localities they are some years plentiful enough.

Vigo county. Terre Haute, Nov. 3, 1890; spring 1891.

Randolph county. Farmland, Jan. 1891. (U. O. Cox).

Wabash county. One specimen, North Manchester (A. B. Ulrey).

10. *Arvicola austerus* (Le C.).

Franklin county. A few specimens have been taken, but it does not appear to be abundant.

Vigo county. Terre Haute, May 1, 1891.

11. *Arvicola pennsylvanicus* Ord. Meadow Mouse.

Franklin, Carroll, Wayne, Vigo and Randolph counties.

Apparently common wherever reported. The most common meadow mouse.

Clinton county. A partial albino taken by C. J. Reynolds at Frankfort in 1890.

12. *Mus rattus* L. Black Rat.

Introduced into America about 1544, but is now being replaced by the succeeding. Included by Dr. Haymond in 1869, Franklin county. None have been reported since.

13. *Mus decumanus* Pallas. Brown Rat; Norway Rat.

Our common rat. Introduced into America about 1775. Appeared in Brookville in the summer of 1827 (Haymond).

14. *Mus musculus* (L.). House Mouse.

Our common species. Introduced—cannot learn the date of its introduction.

15. *Evotomys rutilus gapperi* (?) Coues. Long-eared Mouse.

There is a specimen in the collection of C. L. Reynolds at Frankfort which seems to belong to this species. It was taken near Montmorenci, Tippecanoe county, in 1889.

16. *Calomys americanus* Kerr. Common White-footed Mouse.

Carroll, Monroe and Vigo counties.

I have often caught an old female with young hanging to her teats and carried her by the tail for many rods before the young would drop off. (Evermann).

La Grange county. (Steininger).

Franklin county. Very common. They often infest the dwellings and outbuildings of the country residents. Sometimes nest in woodpecker holes or other cavity in an old snag.

Randolph county (Cox).

17. *Castor fiber* (L.). Beaver.

This was certainly rather common in Indiana in early days. "Beaver lake" was, no doubt, so named because of the presence of beavers there. Mr. C. L. Reynolds says he saw a beaver swimming in the Wabash river about twelve miles above La Fayette, in the summer of 1889. He says he is sure of it. In Sept., 1888, I saw a skull in Mr. Sampson's collection at New Harmony, that was taken near there not many years ago (Evermann).

Mr. S. D. Steininger says there are traces of the beaver still to be seen in La Grange county.

Beavers were formerly found in some numbers in Franklin county. In Bath and Springfield townships were extensive colonies, and the remains of their dams are still to be seen. They were also found along the rivers. In the spring of 1883 Mr. Edward Hughes obtained the skull of a beaver from the alluvial deposit at the mouth of Yellow Bank creek four miles from Brookville. The specimen is in the collection of the Brookville Society of Natural History.

Randolph county. Extinct. Traces of beaver dams still found (Cox).

18. *Arctomys monax* (L.). Ground Hog.

Franklin, Carroll, Monroe and Vigo.

Randolph county (Cox).

Wabash county (Ulrey).

La Grange county (Steininger).

Generally very abundant and very destructive.

19. *Spermophilus tridecemlineatus* (Mitchill). Striped Gopher.

In the summers of 1883 and 1884 I saw perhaps three or four individuals in Tippecanoe township, Carroll county, just west of Pittsburg. In Vigo county it seems to be rather common. I have the skin of one taken near Terre Haute, a few years ago, and given me by Miss Ida Lawrence. Mr. W. S. Blatchley has one taken just north of Terre Haute, in the spring of 1888. Last spring I saw one alive southeast of Terre Haute, and in June last I saw a dead one hanging on the fence, five miles south of the city.

Miss Helen Rankin, who lives three miles north of Terre Haute, tells

me that it is seen on their farm every summer. [Evermann.]

Mr. C. L. Reynolds has one that was taken near La Fayette. He says he has seen them in the grounds of Purdue University.

Mr. W. W. Archibald says it is pretty common in Newton county.

La Grange county (Steininger).

Benton county. Has been reported from both Benton and White counties by Mrs. D. C. Ridgley.

White county. Mr. Charles Dury informs me there are some specimens in the Cuvier club collection, Cincinnati, Ohio, that were taken at Chalmers.

Mr. Jas. O. Dunn reports having kept two striped gophers in a cage for nearly a year.

Dr. C. Hart Merriam informs me that Robert Potter sent him a specimen of this species taken at Austin, Oakland county, Mich., and further that he received a specimen from J. W. Anderson, Lakeville, Oakland county, Mich.

Found in some numbers by Dr. R. M. Byrnes, in 1862, near Middletown, Butler county, Ohio. See Langdon Mammalia of the vicinity of Cincinnati.

20. *Spermophilus franklini* Sabine. Gray Spermophile.

Remington, Jasper county. Abundant.

Monticello, White county (Jas. O. Dunn).

This is the first reported occurrence in Indiana. Further notes on its range in the state are desired.

Dr. C. Hart Merriam informs me that the U. S. Department of Agriculture received a specimen of *S. franklini* in flesh from R. Carroll, Earl Park, Benton county, Indiana, also that J. B. Chesebrough reported its occurrence at Kentland, Newton county. Dr. Merriam writes he has two records, one from Robert Potter, Austin, Oakland county, and the other from J. W. Anderson, of Lakeville, Oakland county, Mich.

21. *Tamias striatus* (L.). Ground Squirrel.

Carroll county. Abundant.

Monroe county. Abundant.

Vigo county. Abundant.

Wabash county (A. B. Ulrey).

Randolph county (U. O. Cox). Common.

Franklin county (Haymond; Butler).

La Grange county (Steininger).

22. *Sciurus hudsonicus* Erxleben. Red Squirrel. Chickaree.

Miami county (J. C. Cunningham).

Fulton county. Shot one near Kewanna, 12-24-'89.

Wabash county (Ulrey; Blatchley).

Randolph county (Cox). Occasionally seen.

Blackford county (Cox). Abundant.

Franklin county (Haymond).

La Grange county (Steininger).

Huntington county. The most common squirrel. Some neighbor boys raised fourteen young in 1892 (W. E. Bardsley).

23. *Sciurus carolinensis carolinensis* Allen. Southern Gray Squirrel.

Franklin county. Some years quite common in this part of the state.

Both forms are found here. The gray squirrel is still plenty enough to be extensively hunted.

24. *Sciurus carolinensis leucotis* Gapper. Northern Gray Squirrel.

Carroll county. Formerly abundant.

Monroe county. Not common now.

Vigo county. Not common now.

Wabash county (Ulrey).

Randolph county (Cox). Common in places.

Franklin county (Haymond).

This squirrel is now much less common than it was fifteen to twenty-five years ago. I have for five years watched the Terre Haute market, and in all that time I have not seen over a dozen gray squirrels, while hundreds of fox squirrels were seen. The few gray squirrels that I did see in the market here came from the lower Wabash somewhere (Evermann).

La Grange county (Steininger).

This form with the other is found in Franklin county, though the numbers vary from year to year.

I myself have not seen a black squirrel for many years, though they were not rare in Carroll county when I was a boy.

It is now agreed that the Black Squirrels are a form of the Northern Gray Squirrel. They were formerly quite common in southeastern Indiana, but are now never seen. The lessening of the numbers of this form, *leucotis*, and the increase of the numbers of the southern form, *carolinensis*, is noted by most of the inhabitants. The older men speak of the disappearance of the black and of the gray squirrels "we used to have," and of the appearance of the reddish gray squirrels, which they term a cross between

the gray and the fox squirrels. Dr. Haymond, 1869, says: "Years ago there were about one-sixth of the squirrels in southeastern Indiana black; in northeastern Indiana nearly half of them were black. There are no black squirrels to be seen in southeastern Indiana, neither has there been for several years. * * The further north I have gone in this state the more black squirrels I have seen." In 1872 the last black squirrel was seen in Franklin county.

25. *Sciurus niger ludoricianus* Allen. Fox Squirrel.

Carroll, Monroe and Vigo counties. Still common in each of these counties.

Wabash county (Ulrey). One in Galbraith's collection with the under parts black.

Randolph county (Cox). One killed near Farmland last summer that was about half black. An uncle of Mr. Cox, several years ago found a nest of young fox squirrels, of which two were red, two white and two black.

Last year a white (albino) squirrel was sent me from Bloomington. It was taken in Brown county.

Two white squirrels were seen occasionally on Coal creek, in Vigo county, last year.

QUERY.—Do we not find melanism and albinism in both gray and fox squirrels?

Fox squirrels remain about stationary as to numbers in Franklin county. Generally the gray squirrels are much more frequent. Albino examples are met with almost every year.

26. *Sciuropterus volans* (L.). Common Flying Squirrel.

Carroll, Monroe and Vigo counties. I have never found this squirrel very common in any of these counties.

April 16, 1890, I found a nest containing two young, south of Terre Haute. They were in a woodpecker's hole in a maple snag, about twenty feet from the ground. I broke the snag at the hole and took the two young and placed them on the ground near the root of the tree. The mother had come out of the hole upon my first striking the tree and flown to another tree near by, where she remained, watching my movements. After some little time, she flew back to the snag. Of course, she seemed disturbed by the changed appearance of things. She looked all about, and finally came down to the ground, took one of the young in her mouth, and ran up to the top of the snag. Pretty soon she flew across to

another tree, perhaps thirty feet away, with the young one in her mouth, and ran up the tree to, perhaps a height of fifty feet, where she found a knot-hole into which she carried the young. In a moment she reappeared and flew back to the snag after the other young. I had, in the meantime, stationed myself by the young, ready to catch the old one when she came to seize it. After several advances and retreats, she finally came and seized it in her mouth and was putting up the snag when I caught her.

On December 16, 1890, I received three live ones from Burlington, Carroll county, that had been caught by J. M. Beck. In felling a tree he found a family of six, three of which he caught and sent to me.

Randolph county. Mr. Cox reports it not so common as it was formerly. He says that on Thanksgiving day, a few years ago, he found fifteen in a small rotten stump, a little higher than a man's head.

Wabash county (Ulrey). This squirrel makes a very interesting pet.

Franklin county. Very abundant in Franklin county. They breed during the sugar making season in early spring. It is remarkable what a number of these animals can be found by going from snag to snag and pounding upon it at that time of the year. I have found their nests in woodpecker's holes in tall sycamores and in various buildings, including dwellings.

La Grange county (Steininger).

27. *Blarina brevicauda* Say. Mole-shrew.

Carroll, Monroe and Vigo counties.

Tippecanoe county. (Reynolds' collection.)

I have seen a good many of these shrews in Monroe county, and a few in Carroll and Vigo. On two occasions I put a shrew and a white-footed mouse in the same tin can, with the same result each time—the shrew ate the mouse (Evermann).

La Grange county (Steininger).

Franklin county. Common.

See my paper "On Indiana Shrews," Proc. Ind. Academy of Science 1891, pp. 161-3, for an account of the insects that were found by Chas. Dury in a nest of this species. (Butler).

Vigo county. One specimen, spring 1891.

Randolph county, 1891 (Cox).

28. *Blarina exilipes* (Baird).

I have seen but four specimens of this little shrew, all of which were

taken by Mr. H. M. Hawley, near Terre Haute. The first one was brought me by him Jan. 18, 1890, the next Oct. 1, 1890 and the next Oct. 10, 1890. Mr. Hawley says it is not very common about his place, but that his cat manages to catch four or five every year. He calls it the bee mole, because it gets into his bee hives and there builds its nest and feeds upon the brood (Evermann).

Franklin county. Sometimes taken.

Randolph county. Farmland, winter 1890 (U. O. Cox).

29. *Blarina platyrhinus* (DeK.). Common Shrew.

Wabash county. A specimen of this shrew was taken by Mr. A. B. Ulrey at North Manchester. This is the only reported occurrence in the state.

30. *Blarina parva* (Say). Least Shrew.

Franklin county (Butler).

Two small shrews, submitted by Mr. E. R. Quick to Dr. Langdon, were referred to Dr. Coues. That gentleman, Jan. 15, 1879, wrote Dr. Langdon: "I have not the slightest doubt that you have the veritable animal of Say (*Sorex parva*) in the specimen you send." It is not uncommon about Brookville.

Marion county (Jordan). Brayton, Ohio Mammals.

Ann Arbor, Washtenaw county, Mich. Reported by Prof. J. B. Steere who, however, informs me that he is not certain of its identity.

31. *Blarina cinerea* (Bach.). Cinereus Shrew.

Jefferson county. A dead shrew, found by me near Hanover, in 1877 was referred to the late Prof. S. F. Baird, and he returned it, saying that it was this species.

32. *Scalops aquaticus* (L.). Common Mole.

Carroll, Monroe and Vigo counties (E).

Tippecanoe county (Reynolds).

Randolph county (Cox).

Franklin county (Haymond; Butler). Many moles taken here are more or less marked with white on throat and lower parts.

Rather common in all the above named counties.

La Grange county (Steininger).

33. *Condylura cristata* (L.). Star-nosed Mole.

The first specimen of this mole taken in Indiana was secured by Mr. J. C. Cunningham, near Denver, Miami county, July 5, 1887. The taking of this specimen was reported by Mr. Evermann at the meeting of the

Academy in December, 1887, this note being afterward published in the American Naturalist, vol. XXII, p. 359. Mr. Butler also examined the specimen and reported it in Journal of the Cincinnati Soc. Nat. Hist. for January, 1888, p. 214. The specimen was deposited in the Museum of the Indiana State Normal School, but was lost in the fire of April 8, 1888.

Miami county. Mr. Wm. Heddleson near Deedsville, captured a Star-nose Mole, March 19, 1894. The specimen is now in possession of Mr. C. F. Fite of Denver. (J. C. Cunningham).

Ernest W. Vickers, Ellsworth, Mahoning county, Ohio, informs me of the occurrence of this species in that county, also in Cuyahoga county near Cleveland.

Prof. J. B. Steere informs me the Star-nosed Mole is abundant at Ann Arbor, Mich. in low swampy ground which has been drained. He has also taken it in Ionia county, Mich.

34. *Vespertilio gryphus* Fr. Cuv. Little Brown Bat.

Carroll county, Monroe county, Vigo county. Common in all of these counties. (E.)

Wabash county. Ulery's collection.

Tippecanoe county. Reynold's collection.

Clinton county. Collection of Mr. Al. Keyes.

La Grange county (Steininger).

Franklin county (Haymond). The most common bat in southeastern Indiana.

35. *Vespertilio gryphus lucifugus* (LeC.).

Vigo county. A specimen taken at Terre Haute in 1889. (Evermann).

36. *Lasionycteris noctivagans* (Le C.). Silvery Bat.

LaPorte county. I have a specimen taken near Michigan City, May 10, 1890, and presented to me by Mrs. D. C. Ridgley.

Franklin county. Has been taken by E. R. Quick.

Marion county. Two specimens in the collection of W. P. Hay, Irvington. One taken in 1886, the other in 1889.

37. *Adelonycteris fuscus* (Beauv.). Brown Bat.

Vigo county. A specimen taken by me in 1889 at Terre Haute. (Evermann).

Franklin county. Identified by Mr. Quick.

38. *Atalapha noveboracensis* Erxleben. Red Bat.

Carroll county, Monroe county, Vigo county. Rather common in all these counties.

Wabash county. Ulrey's collection. Took one at Terre Haute, Sept. 8, 1890.

Franklin county (Haymond). Next to the Little Brown Bat this is perhaps the most common species in southeastern Indiana.

39. *Atalapha cinerea* (Beauvais). Hoary Bat.

White county. A specimen taken in White county (1890) by Miss Eva Chamberlain.

Franklin county (Haymond). Has been taken by E. R. Quick.

40. *Vesperugo carolinensis* (Geoff.). Carolina Bat.

Franklin county. Identified by Mr. Quick.

41. *Cariacus virginianus* (Boddart). Virginia Deer.

Common in the early days.

Franklin county (Haymond—1847, Butler). I have no recent records, unless La Grange county, 1870, (Steininger) be alright.

Ripley county. Only few years ago. (Butler).

42. *Cervus canadensis* Erxleben. Wapiti; Elk.

Franklin county. Was found comparatively rarely in the White water region at the time of its settlement and soon after disappeared. I have evidence of its occurrence in Ripley county subsequent to 1810. Its former abundance was indicated early in the century by the great numbers of antlers to be found in the beds of the streams most of which soon disappeared, but often they are still found buried beneath the surface of the soil.

43. *Bison bison* (L.). Bison; Buffalo.

The Buffalo is on the seal of the state of Indiana, and was no doubt found in the state in an early day. Allen, in Ninth Report of the U.S. Geological and Geographical Survey, 1875, pp. 502, etc., gives all that he could find as to its former distribution in North America. From this it appears that it was at one time abundant over large portions of Indiana. Charlevoix, writing in 1720, says "all the country that is watered by the Onabache and by the Ohio which runs into it, is very fruitful. It consists of vast meadows, well-watered, where the wild Buffaloes feed by thousands." Vaudreuil, writing about the same time, and La Hontan who saw Lake Erie and the surrounding country in 1687, also speak of the Buffalo as being abundant in this region then. See also Audubon's article on the Buffalo given in The Life of Audubon by Mrs. Horace St. John.

Franklin county. Only the earliest settlers and they but once, so far as can be learned, reported the occurrence of the Buffalo in this county

about four miles southeast of Brookville. The last one reported from Ohio was in 1795. They doubtless left Indiana about 1800. That they once were very abundant in the Ohio valley is shown by the abundance of their remains at "Big Bone Lick" in Kentucky. The earlier explorers, too, tell us of their numbers. Col. Croghan, in May, 1765, speaking of Kentucky just below the mouth of the Big Miami river, on the way to "Big Bone Lick," says: "On our way we passed through a fine timbered clear woods: we came into a large road which the Buffaloes have beaten, spacious enough for two waggon to go abreast, and leading straight into the Lick."

44. *Procyon lotor* (L.). Raccoon

Carroll county, Monroe county, Vigo county. Formerly more common than now.

Wabash county (Ulrey). Galbraith's collection.

Randolph county (Cox). Very abundant.

Franklin county. Still found in some numbers.

La Grange county (Steininger).

45. *Ursus americanus* Pallas. Brown, Black or Cinnamon Bear.

Franklin county. No doubt common in Indiana at one time, but there are few exact records. The last Bear was seen in Franklin county about 1839. A few years ago the skull of a bear was found in a hollow tree. It was brought to Dr. Haymond, who turned it over to Mr. Butler. It is now in Mr. Quick's collection.

La Grange county, 1878 (Steininger).

46. *Lutra hudsonica* (Lacépède). American Otter.

Franklin county (Haymond). Mr. C. L. Reynolds tells me that a Mr. Wells, at La Fayette, has an otter that was killed near there not many years ago. It occurred at Venice, Butler county, several years ago. (Dury.)

47. *Mephitis mephitis* (Shaw). Skunk.

Carroll County, Monroe county, Vigo county. Not uncommon in each of these counties, though less so than formerly.

Randolph county. Not common. (Cox).

Wabash county (Ulrey).

La Grange county (Steininger).

Franklin county. Still abundant. E. R. Quick reports the capture of a fine black male in the winter of 1892-3. This seems to be unusual as the general impression is that the males are usually light col-

ored. Is this impression correct?

48. *Taxidea americana* (Boddart). American Badger.

One was killed 2 miles east of Quaker Hill, or 5 miles southwest of Newport, Vermillion county, in 1880, by a cousin of S. B. McCool of Quaker Hill. Reported by Mr. F. T. Peters. Mr. S. D. Steininger, says "the badger has been found in Elkhart, La Grange, Steuben, De Kalb, Noble and Kosciusko counties. Four have been caught in La Grange county within the last ten years, the last one in 1887. Three were caught in the northeast part of Elkhart county in 1888. In 1880 a black one was caught in Noble county, the hide of which was sold to Chas. Edson.

Grant county. A badger was reported taken but could not verify it (E. L. Guthrie).

Franklin county. July 28, 1889 a badger was killed near Metamora.

Upon examining it the gentleman who killed it said two others had been taken the preceding year (1888).

49. *Putorius vison* (Schreber). Mink.

Carroll county, Monroe county, Vigo county. I have seen it occasionally in each of these counties. (Evermann.)

Wabash county (Ulrey). Galbraith's collection.

Randolph county. Common (Cox). Mr. Cox reports that a mink killed 24 half-grown chickens for him in one night two years ago. Each chicken was bitten only through the head.

Tippecanoe county. Reynold's collection.

La Grange county (Steininger).

Franklin county. Not uncommon in certain localities, especially about drift piles along streams. Last year, 1893, the writer saw three minks at one time in daylight about a drift pile within the corporate limits of the town of Brookville. *Putorius nigrescens* (A. and B.). Little Black Mink is not now thought to be a distinct species. Both forms are found in Franklin county.

50. *Putorius erminea* (L.). Weasel.

Carroll county, 1878; Monroe county, 1883; Vigo county, 1890. I have seen the weasel in each of these counties, but never found it common (Evermann).

Wabash county (Ulrey). Galbraith's collection.

Randolph county (Cox). Occasional.

La Grange (Steininger).

Franklin county. Not uncommon. Some reported every year.

51. *Vulpes vulpes* (L.). Red Fox.

Carroll county, Monroe county, Vigo county. Rather common in each of these counties. In Vigo county several "fox drives" are had every winter and from none to three or four foxes caught each time.

Wabash county (Ulrey). Galbraith's collection.

Randolph county. Common. Cox.

La Grange county (Steininger.)

Franklin county. According to Dr. Haymond the Red Fox came into the county about forty years ago. Previous to that time the gray form only was found. They are numerous. Fox drives were much in vogue a few years ago but none have been had for several years.

52. *Urocyon cinereo-argentatus* (Schreber). Gray Fox.

Franklin county. These foxes are numerous; probably as much so as they ever were. (Haymond, 1869). They are still found but are rare. Their shy habits perhaps make them appear less numerous than they are.

53. *Canis lupus* (Say). Wolf.

Periodical reports of "wolves" are heard, but there is no definite record that I have seen. One was said to be in Clay county in 1890.

Franklin county. Formerly found in numbers. Wolves have been reported killed within twenty or twenty-five years but the greater number had disappeared before that time.

Lake county. Several wolves said to be "Prairie Wolves" found along the Kankakee river in the last two years. (M. A. Brannon, 1890).

54. *Lynx canadensis* (Desmarest). Canada Lynx.

Mr. C. L. Reynolds tells me he mounted a Lynx that was killed in 1885, 7 or 8 miles west of Chauncey, Tippecanoe county.

La Grange county, 1875 (Steininger.)

Montgomery county. One was killed Nov. 22, 1890 near Garfield. (David Binford.)

Franklin county. Was formerly found but never common.

55. *Lynx rufus* (Guldenstädt). American Wild Cat.

Franklin county. In 1869 Dr. Haymond noted "occasionally seen but rare." That was about the end of their existence in this county.

Wild cat reports are seen in the papers almost every winter. Definite records are needed.

56. *Felis concolor* L. American Panther.

Franklin county. Formerly found. Known to the early settlers as Pan-

ther, Painter, Cougar, Catamount. Never was common. But few have been seen since 1835. Two young were taken east of Brookville in 1838. None have been reported for thirty years or more. Other definite records needed.

SPECIES CONCERNING WHICH FURTHER KNOWLEDGE IS DESIRABLE REGARDING
THEIR POSITION IN THE INDIANA FAUNA.

Nycticejus humeralis O. Thomas. Twilight Bat. Pennsylvania to Nebraska and South.

Scapanus americanus (Bartram). Hairy-tailed Mole. Massachusetts to Ohio. Adams county, Ohio.

Scalops argentatus A. and B. Prairie Mole. Silvery Mole. Michigan to Louisiana and West.

Neosorex palustris (Rich.). Water Shrew. Massachusetts to Rocky Mountains and North.

Sorex forsteri (Rich.). Forster's Shrew. Northern U. S. to Pennsylvania.

Sorex cooperi Bach. Cooper's Shrew. Massachusetts to Nebraska and North.

Brachysorex harlani (Duver.)

Brachysorex brevicaudatus (Duver.)

Amphisorex leucurii (Duver.)

These three last species were described by Duvernoy in 1842. The two former from New Harmony, Ind. The latter from Wabash valley, Ind. Their present relationship are not known.

Ochetodon humilis (A. and B.). Harvest Mouse. South Carolina to Iowa, Utah and South.

Calomys palustris Harlan. Rice-field Mouse. New Jersey to Kansas and South. Madisonville, Hamilton county, Ohio, 1876 (Langdon).

Calomys michiganensis (A. and B.). Michigan Field Mouse. Michigan to Illinois and Kansas.

Calomys aureolus (A. and B.). Red Mouse. Pennsylvania to Illinois and South.

Neotoma floridana Say and Ord. Wood Rat. New York to Colorado, Arizona and South.

Lepus palustris Bach. March Hare. North Carolina to South Illinois and South in Swamps.

Lepus aquaticus Bach. Water Hare. South Illinois to Louisiana and Southwest in canebrakes and about lowland streams.

Mephitis putorius (L.). Little Striped Skunk. Wisconsin to Georgia and Southwest.

A CONTRIBUTION TO A KNOWLEDGE OF INDIANA MOLLUSCA.**BY R. ELLSWORTH CALI.**

The wonderful diversity of physical features in Indiana contributes to the development of an interesting molluscan fauna. Swamp, pond, creek and river each presents forms or groups of forms characteristic of such stations; hillside, river bottom, prairie, contributes each its own peculiar species. So that in a state of such widely different natural conditions it is not surprising that a great array of forms, most of which are by no means conspicuous, should have been discovered.

There has never been made a geographic study, within this state, of its mollusks. Nor have systematic collections ever been made of so much as even a single stream. One could name on the fingers of the hands the men and the places which have thus far yielded our sole knowledge of Indiana mollusks. It is the object of this paper to state, in a few words, the present condition of our information in this line and to indicate if possible, the direction along which future effort should be made.

It does not need words of mine to demonstrate that the first essential condition to a complete study of the geographic distribution of Indiana mollusca lies in complete and painstaking local collections. This is not the task of a week nor of a single season. The habits of our mollusks are so peculiar that certain seasons present sometimes many forms which fail to appear again for several successive years. Often, even in the case of the most common species, numbers of individuals are spasmodically great; then years go on and few of certain forms are to be found. No less interesting will be the life history of these retiring animals. Not the life history of a single Indiana species is known. And, so far as my information goes, there is not a student in the state who is doing more than collect the pretty and variously ornamented shells that they may grace a cabinet! What their biological significance may be in that great sum which makes up the animal life of Indiana no one seems to be investigating.

A further necessity for immediate action that the original inhabitants of the state may be listed lies in the danger of extinction of very many forms. The sewerage of towns and villages, the refuse of factories and other manufacturing plants, the gradual encroachment on the primitive forests, the drying up of streams, the drainage of swamps, the general increase in tilled lands, these all conspire against the chances of perpetuity of a rich molluscan fauna. What is done must be systematically done

and thoroughly and at once.

This "Contribution" seeks to do little more than to call attention to a neglected branch of animal life which will yield the student a mass of valuable data and prove a veritable mine of pleasure. In it there has been given simply, without attempt to discuss any scientific question, a list of the forms credited to the state. Very many of those mentioned have been seen within the state or in collections containing authentic specimens. Others are listed on the authority of undoubtedly correct writers. How much has been already accomplished and what yet remains to do the lists themselves will indicate.

The general plan of simply naming a single locality, at most two or three, has been followed in order that a definite locality within the state would fix the form as belonging to the Indiana fauna. Not a single form has been admitted that has been recorded from neighboring states notwithstanding that such a course would have been justifiable on the ground that the artificial lines imposed by state boundaries are unknown to mollusks, and species found in localities close to Indiana may reasonably be expected within its limits. This course would have largely increased our list, but it was preferred to make a record only of those shells known in the state. The student may rest assured that every species named herein has been found in Indiana and will be found again.

An attempt at a bibliography has been made. But works or papers dealing with our shells solely are very few in number. General works there are, quite numerous too, from which help may be had. These two classes of information are given below in separate lists. The paucity of literature pertaining to this state will be evident at a glance.

The Ohio river has been a prolific source of Unionida. From that stream come most of the forms of wide geographic distribution; indeed, most of them were originally made known from that river. The Wabash and the White rivers have contributed many forms but most of them are common to the Ohio. It has been the rule to insert in this list of Indiana shells all the species which were originally described from the Ohio whether there is special record of their occurrence within the limits of the state or not.

In every portion of the commonwealth it is hoped that persons will become interested in these animals sufficiently to collect locally and send to some central point what may be found, in order that a complete list, with distribution, varietal characters, and other facts of a biologic nature may

be eventually prepared. It is hoped every reader of this preliminary paper will become personally interested in the matter.

BIBLIOGRAPHY. A.—GENERAL WORKS.

This list includes general faunal lists and general descriptive works in North American Conchology. In all of them are to be found matters of more or less interest to the student of Indiana mollusca.

Poulson, C. A. A Monograph of the Fluvial Bivalve Shells of the river Ohio, containing twelve genera and sixty-eight species. 1832.

A translation of Rafinesque's older work, which see.

Say, Thomas, F. M. L. S. American Conchology, or Descriptions of the Shells of North America. New Harmony, Indiana. 1830-1834.

Illustrated by colored figures from original drawings executed from nature.

Conrad, T. A. Monograph of the Family Unionidæ. 1835-1839.

Lea, Isaac. LL. D. Observations on the Genus Unio. 13 volumes, 4to. 1830-1874.

These volumes were originally published as portions of the Transactions of the American Philosophical Society and of the Journal of the Philadelphia Academy of Sciences. They were afterwards collated and issued separately under the above title.

———A Synopsis of the Family Unionidæ. Four editions. 1830-1870.

This work has almost a complete bibliography of the Unionidæ, particularly the American forms. There are also tables of geographical distribution, but these are little more than a mere list of the original localities for the American species.

Catalogue of the Unios, Alasmodontas and Anodontas of the Ohio river and its northern tributaries, adopted by the Western Academy of Natural Sciences of Cincinnati. January, 1849, pp. 19.

There are listed in this remarkable little brochure fifty-six species of *Unio*, six of *Margaritana*, and five of *Anodonta*. The catalogue is remarkable as being the first open expression hostile to the claims of both Say and Rafinesque. It marks the beginning of a long and bitter controversy, from the effects of which American malacology has not yet fully recovered.

Binney, Amos. Terrestrial Air-breathing Mollusks of the United States. Boston, 1851. Three volumes—text, two volumes; plates, one volume.

Lea, Isaac. Check list of the shells of North America. *Unionidæ*. Washington, 1860.

This is a mere list of species without definite locality references.

Prime, Temple. Check list of the shells of North America. *Cyclades*. Washington, 1860.

Same limitations as the work last cited.

Binney, W. G. Check list of the shells of North America. *Terrestrial Gasteropoda*. Washington, 1860. Second edition.

List number II of this work is general for that portion of the United States which includes Indiana.

———Check list of the shells of North America. *Fluvialile Gasteropoda*. Washington, 1860.

Rafinesque, Constantine Smaltz. The complete writings of, on recent and fossil Conchology. Edited by Wm. G. Binney and George W. Tryon, Jr. New York, 1864.

This work gives all the published work of Rafinesque in this department of science and is an indispensable adjunct where justice and fairness govern in determining the claims of authors. It has been misconstrued and misinterpreted; its value has not always been recognized.

Stimpson, William. Smithsonian Miscellaneous Collections. 201. Researches on the *Hydrobiinae* and allied forms. Washington, 1865.

Prime, Temple. Smithsonian Miscellaneous Collections. 145. Monograph of American *Corbiculadae*, recent and fossil. Washington, 1865.

Binney, Wm. G. Smithsonian Miscellaneous Collections. 143. Land and fresh water shells of North America. Part II. *Pulmonata Limnophila* and *Thallasophila*. Washington, 1865.

Tryon, George W., Jr. A Monograph of the Terrestrial Mollusca inhabiting the United States. New York, 1866.

Lea, Isaac. Rectification of T. A. Conrad's Synopsis of the Family of Naiades of North America. New edition. Philadelphia, 1872.

Tryon, George W., Jr. Smithsonian Miscellaneous Collections. 253. Land and Fresh-water shells of North America. Part IV. *Strepomatidae*. Washington, 1873.

Harper, George W., and Wetherby, A. G. Catalogue of the land and fresh water Mollusca found in the immediate vicinity of Cincinnati, Ohio. Cincinnati, 1876.

This brochure, which originally appeared in the Journal of the Cincinnati Society of Natural History, is very valuable as an indicator of what the collector may expect in the Ohio along the shores of Indiana. It lists seventy-four *Unios*, eight *Margaritanas* and nine *Anodontus*.

Lewis, James, M. D. On *Unio subrostratus* Say. In Proceedings of the Academy of Natural Science of Philadelphia. 1878. Reprint, p. 4.

Contains some valuable information concerning a shell originally described from this state.

Binney, Wm. G. Terrestrial Air-breathing Mollusks of the United States and the adjacent territories of North America. Bull. Museum

Comparative Zoology. vol. IV. 2 volumes, 1878.

Call, R. Ellsworth. Geographic Distribution of the *Unionidae* of the Mississippi Valley. Bull. Des Moines Academy of Science, vol. 1, number 1, pp. 5-56. 1885.

Binney, Wm. G. Bulletin United States National Museum, No. 28. A manual of American land shells. Washington, 1885.

Wright, Berlin Hart. Check list of North American *Unionidae* and other fresh water bivalves. Portland, Oregon, 1888.

B.—LOCAL LISTS AND SPECIAL REPORTS.

Plummer, Dr. John T. Scraps in Natural History (Mollusca). American Journal of Science and Arts, O. S., vol. XLVIII, No. 1, pp. 93-96. 1844.

This paper gives a list of shells found about Richmond, Wayne county, Indiana. There are in it the names of twenty-one species of land shells, eight univalve fresh water forms, one *Anodon*, two *Margaritanas*, and one *Sphaerium*.

Pleas, E. Shells of Henry county. In "The Nautilus," vol. VII, No. 6, pp. 68-70. 1893.

This paper lists fifty-nine species and varieties of land mollusks and sixty-four species and varieties of fresh water forms. They were all found within five miles of Dunreith. There will, doubtless, be some question of correct indentifications.

Department of Geology and Natural History. Indiana. 16th Annual Report, pp. 428-468. 1889.

This volume gives a mere list of the contents of certain cases in the State's Museum, and is absolutely valueless for any conceivable purpose. Many of the forms listed are, doubtless, from this state, but in the absence of locality references the list has no value to the student. The proof-reading is a marvel of carelessness.

Moore, D. R., and Butler, A. W. Land and fresh water Mollusca observed in Franklin county, Indiana. See Bull. of the Brookville Society of Natural History, No. 1, pp. 41-44. 1885.

This really valuable paper gives a list of some thirty-eight species and varieties of land shells, ten species of fresh water univalves, and fifteen species of fresh water bivalves. Of the latter, seven belong to *Unio*, three to *Margaritana* and four to *Anodonta*. One belongs to *Sphaerium*.

Say, Thomas. Descriptions of several new species of shells and of a new species of *Lumbricus*. Transylvania Journal of Medicine, vol. IV. 1831.

On pp. 525-529 occur several descriptions of shells, among which one *Unio* (*Unio capillus*) from the Wabash river and one land shell (*Helicina occulta*) from near New Harmony are found.

Cox, E. T., State Geologist. Geological Survey of Indiana. Annual Report for 1875.

This volume contains a paper by G. M. Levette, entitled, "Observations on the Depth and Temperature of some of the Lakes of Northern Indiana." There is given in the paper a list of fifteen *Unios*, one *Margaritana*, four *Anodons* and nineteen species and varieties of fresh water univalves. The list, except the portion pertaining to the *Unionidae*, was prepared by Mr. John W. Brykit, of Indianapolis. It is intended to cover only northern Indiana.

Stein, Fred. Geological Survey of Indiana. Annual report for the year 1880. Pp. 451-467. Contains the molluscous fauna of Indiana.

There are listed the *Uniones*, *Margaritanas*, *Anodontas*, and other fresh water bivalves, of several genera and species. Besides these there are given the genera and species of fresh water univalves, and all the known species and varieties of land shells. This list bears the distinction of being the very first to endeavor to present a complete view of the shell-life Indiana.

Species described from Indiana.

In collating the lists of mollusks known from this state it has been matter of great interest to note those which had an original habitat ascribed to some part of Indiana. This was to be expected, perhaps, since the earliest of the best known and most scientific writers in conchology, Thomas Say, was for a long time a resident of that interesting colony—the basal principle of which was a kind of Utopian doctrine of communism—which founded New Harmony. While resident here, under the inspiration of association with such men as Troost, Maclure, and the older Owen, opportunity was afforded Say to collect and examine very many of the mollusks of the region. He improved the occasion, as we well know, and gave to the world of science its best early American contributions to conchology. Since his day other species have been found, supposed to be new and described as such by various authors until the list has grown to very respectable proportions. While some of the names following are properly recognized as synonyms yet they are given with the reference to the forms which have priority, for it is but fair to the workers of other days that we recognize the disadvantages of long distance from scientific centers and the other untoward conditions of life in a practical wilderness.

LAND SHELLS.

HELICINA OCCULTA Say. Near New Harmony.

SUCCINEA VERMETA Say. New Harmony.

POLYGYRA FASTIGIATA Say. New Harmony.

FRESH WATER UNIVALVES.

ANCYLUS TARDUS Say. Wabash river.

VIVIPARA SUBPURPUREA Say. Wabash river.

CAMPELOMA PONDEROSUM Say. Ohio river.

PLEUROCERA CANALICULATUM Say. Falls of the Ohio.

PLEUROCERA MONILIFERUM Lea. New Harmony.

PLEUROCERA ANTHONYI Lea. Fox river, "Indiana."

PLEUROCERA TROOSTII Lea. Near New Harmony.

LITHASIA OBOVATA Say. Wabash and Falls of the Ohio.

ANGITREMA VERRUCOSA Say. Wabash river.

ANGITREMA ARMIGERA Say. Wabash river.

MELANIA NUPERA Say. Wabash river.

=*ANGITREMA VERRUCOSA*. Wabash river.

ANCULOSA PRÆROSA Say. Falls of the Ohio.

ANCULOSA TRILINEATA SAY. Falls of the Ohio.

GONIOBASIS DEPYGIS Say. Falls of the Ohio.

GONIOBASIS INTERSITA Haldeman. Swan creek.

This species was based on specimens furnished by Mrs. Say after the death of her husband.

GONIOBASIS CONSANGUINEA Anthony. "Indiana."

GONIOBASIS BICOLORATA Anthony. Camp creek, near Madison.

GONIOBASIS CUBICOIDES Anthony. Wabash river.

GONIOBASIS INFANTULA Lea. Falls of the Ohio.

GONIOBASIS LOUISVILLENSIS Lea. Falls of the Ohio.

GONIOBASIS INTERLINEATA Anthony. Christy creek.

GONIOBASIS SPARTANBURGENSIS Lea. Wabash river.

GONIOBASIS INFORMIS Lea. Falls of the Ohio.

GONIOBASIS KIRTLANDIANA Lea. "Indiana."

=*GONIOBASIS SEMICARINATA* Say. Richmond.

=*GONIOBASIS BICOLORATA* Anthony. Camp creek.

MESECHIZA GROSVENORII Lea. Wabash river.

This genus is now recognized to have been based upon pathologic specimens of a *Goniobasis*, probably *Goniobasis cubicoidea* Anthony. The specimens were not only pathologic but immature. The writer has several times, in streams in the South, noted many specimens of traumatic shells which might easily be referred to this genus.

FRESH WATER BIVALVES.

UNIO ABRUPTUS Say. Wabash river.

UNIO ORBICULATUS Hildreth.

UNIO ARQUATUS Conrad. Wabash river.

=UNIO RECTUS Lamarck. Pathologic.

UNIO CAPILLUS Conrad. Wabash river.

=UNIO FABALIS Lea. Ohio river

UNIO CICATRICONUS Say. Wabash river.

=UNIO VARICOSUS (?) Lea.

UNIO CYLINDRICUS Say. Wabash river.

UNIO ELEGANS Lea. Wabash and Ohio rivers.

UNIO HEROS Say. Wabash river.

=UNIO MULTIPLICATUS Lea.

UNIO MYTILOIDES Rafinesque. Wabash river.

UNIO PERSONATUS Say. Wabash river.

UNIO PHILLIPSI Conrad. Wabash river.

UNIO SAMPSONII Lea. Wabash river.

=UNIO PERPLEXUS Lea.

UNIO SECURIS Lea. Ohio and Wabash rivers.

UNIO SULCATUS Lea. Wabash and Ohio rivers.

UNIO UNDULATUS Barnes. Wabash river.

MARGARITANA CONFRAGOSA Say. Wabash river.

MARGARITANA DEHISCENS Say. Wabash river.

=UNIO DEHISCENS Say.

MARGARITANA MONODONTA Say. Wabash and Ohio rivers.

=UNIO MONODONTA Say. From Falls of the Ohio.

ANODONTA EDENTULA Say. "Indiana." Locality not given.

ANODONTA FERRUGINEA Lea. Simon's creek.

ANODONTA IMBECILLIS Say. Wabash river.

ANODONTA SUBORBICULATA Say. Ponds near Wabash river.

A summary of this list of shells originally described from Indiana shows three species of land shells; twenty-nine species of fresh water univalves; and twenty-one species of *Unionidae*. While several of these have been relegated to the standing of pure synonyms they yet serve a useful purpose in determining the exact nature of the molluscan fauna. It may be that more extended opportunities in the matter of literature will add to this list other forms, thus enriching the original contributions of Indiana to conchologic lore.

GENERAL LIST OF MOLLUSCA.

In the following lists there has been no serious attempt to classify the shells of the state in any systematic manner. At the present time geographical distribution is the most important feature. In pursuance of this object, the arrangement is chiefly alphabetical. Only in a few instances have data which give exact localities been attainable. In seeking to enlarge the list hereafter only specimens accompanied with exact locality references should be admitted.

A number of shells listed from Indiana in various amateur papers, and known to belong to a fauna entirely different, have been excluded as not being authentic. No injustice is done any student by relegating these forms to a doubtful list and awaiting the result of careful examination within the state. Should such examination reveal the forms so excluded it will be a source of congratulation that so many extralimital shells should be found in Indiana.

Register of Land Forms.

Conulus fulvus Draparnaud.

Helicina occulta Say. New Harmony.

Helicodiscus lineatus Anthony.

Limax flavus Linnæus. New Albany.

This form is very abundant in and about Louisville, Ky., having been introduced through commerce.

Limax campestris Say. Franklin county.

Limax (Tebennophorus) carolinensis Bosc.

Limax (Tebennophorus) dorsalis Binney.

Mesodon albolabris Say. All over the state.

Mesodon clausa Say. Southern Indiana.

Mesodon exoletus Binney. Indianapolis.

Mesodon mitchelliana Lea. Franklin county.

Mesodon multilineata Say. All over south Indiana.

Mesodon profunda Say. Indianapolis; Madison; Charleston.

Patula alternata Say. Generally distributed.

Patula perspectiva Say. Indianapolis.

Patula solitaria Say. Indianapolis; Charleston.

Patula striatella Anthony. Indianapolis; New Albany.

Polygyra fastigiata Say. New Harmony.

Polygyra leporina Gould. No specimens seen.

Pupa armifera Say. Bloomington; Indianapolis.

- Pupa contracta* Say. Bloomington.
Pupa corticaria Say. Indianapolis.
Pupa fallax Say. Indianapolis; Bloomington.
Pupa muscorum Linnæus. Bloomington.
Pupa pentadon Say. Bloomington.
Pupa rupicola Say. Franklin county.
Selenites concava Say. Generally distributed.
Stenotrema hirsutum Say. Generally distributed.
Stenotrema monodon Rackett. Generally distributed.
Stenotrema monodon fraternum Say. Indianapolis.
Stenotrema monodon leaii Ward. Indianapolis.
Stenotrema stenotrema Ferussac. Indianapolis; Madison.
Succinea avara Say. Generally distributed.
Succinea obliqua Say. Credited to state.
Succinea oralis Gould. Indianapolis.
Succinea totteniana Lea. Vincennes.
Succinea vermata Say. New Harmony.
Strobila labyrinthica Say. South Indiana.
Triodopsis appressa Say. Indianapolis; Madison.
Triodopsis fallax Say. Indianapolis.
Triodopsis inflecta Say. Indianapolis; south Indiana.
Triodopsis obstricta Say. Indianapolis.
Triodopsis palliata Say. Generally distributed over central and northern Indiana.
Vallonia pulchella Muller. Indianapolis; Bloomington.
Vertigo gouldii Binney.
 Very doubtful determination. Probably some other form was really in the hands of the authority.
Vertigo ovata Say. Generally distributed.
Zonites arboreus Say. Indianapolis; generally over the state.
Zonites friabilis W. G. Binney. New Harmony.
Zonites fuliginosus Griffith. Indianapolis; Charleston.
Zonites milium Morse. Southern Indiana.
Zonites nitidus Muller. Generally distributed.
Zonites indentatus Say. Franklin county.
Zonites inornatus Say. Referred to Indiana.
Zonites intertextus Binney. Authority of Binney.
Zonites ligerus Say. Indianapolis; southern Indiana.

Zonites limatulus Ward. Indianapolis; generally distributed.

Register of Fresh Water Univalves.

Carychium eriguum Say. In all damp places under leaves.

This is one of the most minute of American shells.

Ancylus tardus Say. Wabash, White and Ohio rivers.

Bulinus hypnorum Linnæus. Indianapolis; northern Indiana.

Helisoma bicarinatus Say. Indianapolis.

Planorbis trivolvis Say. Indianapolis; generally distributed over the state.

Limnophysa columella Say. Credited to Indiana.

Limnophysa caperata Say. Indianapolis; Wabash river.

Limnophysa desiliosa Say. Indianapolis; generally distributed over the state.

Limnophysa humilis Say. All over the state.

Limnophysa palustris Muller. Generally distributed.

Limnophysa reflexa Say. Indianapolis.

Menetus eracutus Say. Generally distributed in ponds.

Physa gyrina Say. All over the state.

Physa heterostropha Say. All over the state.

Valvata tricarinata Say. Credited to the state.

Somatogyrus isogonus Say. White river; Wabash river.

Pomatiopsis lapidaria Say. Wabash river. Probably generally distributed.

Campeloma apertum Lewis. (Ms.) West Fork White river.

=*Campeloma integrum* DeKay.

Campeloma decisum Say. St. Joseph river.

Campeloma integrum DeKay. St. Joseph river.

Campeloma ponderosum Say. Wabash and Ohio rivers.

Campeloma rufum Haldeman. St. Joseph and White rivers.

Campeloma regularis Lea. Ohio river.

=Junior *C. ponderosum* Say.

Campeloma subsolidum Anthony. Wabash river.

Lioplar subcarinata Say. Laporte.

Vivipara contectoides Binney. Wabash river.

Vivipara subpurpurea Say. Wabash river.

Anculosa prarosa Say. Falls of the Ohio.

Anculosa trilineata Say. Falls of the Ohio.

Angitrema armigera Say. Wabash river.

Angitrema nupera Say. Wabash river.

=*Angitrema verrucosa* Say.

Angitrema verrucosa Say. Wabash and Ohio rivers.

Goniobasis bicolorata Anthony. Camp creek, Madison.

Goniobasis consanguinea Anthony. "Indiana."

It is probable that a no more satisfactory author than this one ever wrote on American shells. Exact localities are rarely ever mentioned by him, and most of those given are open to serious question. He was notorious for looseness in this very important matter. Rarely can his references be used for geographic distribution.

Goniobasis cubicoides Anthony. Wabash river.

Goniobasis depygis Say. Falls of the Ohio.

This is one of the most abundant shells at the falls, and at low water may be secured by the gallon with very little effort.

Goniobasis infantula Lea. Falls of the Ohio.

=*Goniobasis depygis* Say.

Goniobasis informis Lea. Falls of the Ohio.

Goniobasis interlineata Anthony. Christy creek.

=*Goniobasis semicarinata* Say.

Goniobasis intersita Haldeman. Swan creek.

Goniobasis louisvillensis Lea. Falls of the Ohio.

=*Lithasia obovata* Say.

Goniobasis kirtlandiana Lea. "Indiana."

=*Goniobasis bicolorata* Anthony.

=*Goniobasis semicarinata* Say.

Goniobasis semicarinata Say. Richmond; Franklin Co.

Goniobasis spartenbergensis Lea. Wabash river.

=*Goniobasis depygis* Say.

Lithasia obovata Say. Wabash river; Falls of the Ohio. Very abundant at the last locality.

Meseschiza grosvenerii Lea. Wabash river. Pathologic form.

Pleurocera anthonyi Lea. "Fox river, Indiana."

There is considerable uncertainty about this locality reference. Fox river is in Illinois.

Pleurocera canaliculatum Lea. Falls of the Ohio.

A very abundant and exceedingly variable shell.

Pleurocera elevatum Say. Ohio river.

Pleurocera moniliferum Lea. Wabash and Ohio rivers.

Pleurocera simplex Lea. Ohio river.

Pleurocera troostii Lea. New Harmony, Wabash river.

This species was based upon specimens submitted to Dr. Lea from very widely separated localities. The greater number came from North Alabama and Georgia. There is very much doubt that this species was found in the northern locality to which it is credited.

Pleurocera undulatum Say. Ohio river.

FRESH WATER BIVALVES.

Pisidium abditum Haldeman. Ohio river. Probably generally distributed over the state.

Pisidium virginicum Bourgiuignat. Ohio river.

Sphaerium solidulum Prime. Franklin county.

Sphaerium sphaericum Anthony. Ponds along Wabash river.

Sphaerium stamineum Conrad. Ohio river.

Sphaerium sulcatum Lamarck. Ohio river.

Sphaerium transversum Say. Ohio and Wabash rivers.

Anodonta decora Lea. Ohio river.

Anodonta edentula Say. Wabash, White and Ohio rivers; lakes in northern Indiana.

Anodonta ferruginea Lea. Simon's creek.

Anodonta ferussaciana Lea. Ohio river; Lakes in northern Indiana.

Anodonta footiana Lea. South Bend.

Anodonta grandis Say. Flat Rock creek; Wabash river. Probably distributed all over the state.

Anodonta imbecillis Say. Wabash and Ohio rivers; Canal at Indianapolis.

Anodonta paronia Lea. Flat Rock creek.

Anodonta plana Lea. Ohio river; Flat Rock creek.

Anodonta salmonia Lea. Blue river.

Anodonta shæfferiana Lea. Flat Rock creek.

Anodonta subcylindracea Lea. White river.

Anodonta suborbiculata Say. Ponds near Wabash river.

Anodonta wardiana Lea. White river.

Margaritana calceola Lea. Ohio river; Flat Rock creek.

= *Margaritana deltoidea* Lea.

Margaritana complanata Barnes. Ohio and White rivers.

Margaritana confragosa Say. Ohio and Wabash rivers.

Margaritana dehiscens Say. Wabash and Ohio rivers.

Described as *Unio dehiscens* Say.

Margaritana deltoidea Lea. Wabash, White and Ohio rivers.

Margaritana hildrethiana Lea. Ohio river.

Margaritana marginata Say. White river.

Margaritana monodonta Say. Falls of the Ohio river; Wabash river.

Described as *Unio monodontus* Say.

Margaritana rugosa Barnes. Wabash and Ohio rivers; Lakes in northern Indiana.

Unio abruptus Say. Wabash river.

— *Unio orbiculatus* Hildreth.

Unio æsopus Green. Ohio river.

Unio alatus Say. Ohio, White and Wabash rivers.

Unio anodontoides Lea. Ohio and Wabash rivers.

Described as *Unio teres* Rafinesque, from the Wabash.

Unio arctior Lea. White, Wabash and Ohio rivers.

— *Unio gibbosus* Barnes, white nacre variety.

Unio arquatus Conrad. Wabash river.

— *Unio rectus* Lamarck, pathologic.

Unio asperrimus Lea. Wabash and Ohio rivers.

Unio camelus Lea. Ohio river.

— *Unio phaseolus* Barnes.

Unio phaseolus Barnes.

Unio camptodon Say. Ohio river.

Unio capax Green. Ohio river.

Unio cicatricosus Say. Wabash river.

— *Unio varicosus* Lea.

Unio cincinnatiensis Lea. Ohio river.

— *Unio perplexus* Lea.

Unio circulus Lea. Wabash, White and Ohio rivers.

Unio clavus Lamarck. Wabash, White and Ohio rivers.

Unio coccineus Lea. Wabash and Ohio rivers.

Unio cooperianus Lea. Ohio river.

Unio cornutus Barnes. Wabash and Ohio rivers.

Unio crassidens Lamarck. Wabash and Ohio rivers.

Unio cylindricus Say. Wabash and Ohio rivers.

Unio distans Anthony. St. Joseph river.

= *Unio luteolus* Lamarck.

Unio donaciformis Lea. Wabash river; Ohio river.

Unio dorfeuillianus Lea. Ohio river.

Unio ebenus Lea. Ohio and Wabash rivers.

Unio elegans Lea. Wabash and Ohio rivers.

Unio ellipsis Lea. Ohio and Wabash rivers.

Unio fabalis Lea. Ohio river.

Unio foliatus Hildreth. Ohio river.

Unio fragosus Conrad. Wabash and Ohio rivers.

Unio gibbosus Barnes. Lakes in northern Indiana; Ohio, White and Wabash rivers.

Unio glans Lea. Ohio and White rivers; lakes in northern Indiana.

Unio gracilis Barnes. Ohio river.

Unio graniferus Lea. Ohio river.

Unio heros Say. Wabash river.

= *Unio multiplicatus*. Lea.

Unio iris Lea. St. Joseph's, White and Ohio rivers; lakes in northern Indiana.

Unio irroratus Lea. White and Ohio rivers.

Unio lachrymosus Lea. Ohio river. *Unio asperrimus* Lea is a synonym of this form.

Unio levissimus Lea. White and Ohio rivers.

Unio lens Lea. Canal, Indianapolis; Ohio river.

= *Unio circulus* Lea.

Unio ligamentinus Lamarck. Wabash and Ohio rivers.

Unio luteolus Lamarck. Lakes in northern Indiana; Ohio river. Probably generally distributed.

Unio metanervus Rafinesque. Wabash, White and Ohio rivers.

Unio multiradiatus Lea. Canal, Indianapolis; White river.

Unio multiplicatus Lea. Ohio and Wabash rivers.

Unio mytiloides Rafinesque. Ohio and Wabash rivers.

Unio nasutus Say. Lakes in northern Indiana. Only in those which drain into the Great lakes.

Unio obliquus Lamarck. Ohio and Wabash rivers.

Unio occidentalis Lea. Ohio river.

= *Unio ventricosus* Barnes.

Unio orbiculatus Hildreth. Ohio and Wabash rivers. See *Unio abruptus* Say.

Unio ovatus Say. Ohio river.

Unio parrus Barnes. Ohio river; Wabash river. Probably over a great portion of the state.

Unio perplexus Lea. Wabash and Ohio rivers.

Unio personatus Say. Wabash river.

Unio phaseolus Barnes. Wabash, White and Ohio rivers.

Unio phillipsii Conrad. Ohio and Wabash rivers. .

-- *Unio perplexus* Lea.

Unio plenus Lea. Wabash and Ohio rivers.

Unio plicatus Lesueur. Ohio river.

Unio pileus Lea. Ohio river.

-- *Unio personatus* Say

Unio pressus Lea. Lakes in northern Indiana; Canal at Indianapolis; Ohio river.

Unio pustulatus Lea. Ohio river.

Unio pustulosus Lea. Wabash and Ohio rivers.

Unio pyramidatus Lea. Ohio and Wabash rivers.

Unio rangianus Lea. Ohio and White rivers; Wild Cat creek, Carroll county.

-- *Unio perplexus* Lea.

Unio rectus Lamarck. Ohio and Wabash rivers.

Unio retusus Lamarck. Ohio and Wabash rivers.

Unio rubiginosus Lea. Lakes in northern Indiana; Ohio and White rivers.

Unio sampsonii Lea. Wabash river.

-- *Unio perplexus* Lea.

Unio securis Lea. Ohio and Wabash rivers.

Unio solidus Lea. Wabash and Ohio rivers.

Unio spatulatus Lea. Lakes in northern Indiana.

Unio suboratus Lea. Ohio and White rivers.

Unio subrostratus Say. South Bend; Wabash river.

Unio subrotundus Lea. Ohio river.

Unio sulcatus Lea. Wabash and Ohio rivers.

Unio tenuissimus Lea. Ohio river.

Unio triangularis Barnes. White and Ohio rivers.

Unio trigonus Lea. Ohio river, Wabash river.

Unio tuberculatus Barnes. White, Wabash and Ohio rivers.

Unio undulatus Barnes. Wabash and Ohio rivers.

Unio varicosus Lea. Ohio river.

Unio ventricosus Barnes. Ohio river; lakes in northern Indiana.

Unio verrucosus Barnes. Wabash and Ohio rivers.

Unio zigzag Lea. Ohio river, Wabash river.

= *Unio donaciformis* Lea.

Summarizing the data herein presented, exclusive of synonyms and doubtful forms referred to the state by writers, we find the following totals: Of land shells, 17 genera and 58 species; of fresh water univalves, 18 genera and 47 species; of fresh water bivalves, 5 genera and 102 species. That the number of species will be largely increased on careful examination there can be no question.

Louisville, Ky., Nov. 30, 1893.

GEOLOGY.

GEOLOGICAL LITERATURE OF INDIANA—(STRATIGRAPHIC AND ECONOMIC).

By VERNON F. MARSTERS AND E. M. KINDLE.—Geological Department, Indiana University.

The following alphabetical list of the contributions to Indiana Geological literature includes such as deal especially with the physical and economic phases of the subject, and only brief references to the larger and more important contributions to the paleontology of the state. This list is so arranged that the student can ascertain: First, what *counties* of the state have been subject to investigation, second, *by whom* the work was done, third, *where the results are published*, fourth nature and results of the investigations. A brief statement of the contents of the more important papers, Reports, etc., is placed under the *author's name*. The references of an *economic* phase are placed under the heading *Economic Geology* which comes in its proper place in the alphabetic series. Under this heading are placed the following subdivision: *Clays, coals, gas, hydraulic cements, oil, ore (minerals), stone (building)*. The reference to the paleontology of the state are not included *in detail* in this list for the reason that they demand a somewhat different treatment in order to make the treatise the most useful to the student.

Adams county, Geology of. R. Owen's Rep. 1859-60.

Allen county, Geology of. R. Owen's Rep. 1859-60.

———Geology of. M. Thompson's Rep. 1888.

Altitudes, table of, in Indiana and elsewhere. Owen's Rep. 1859-60.

Bartholomew county, Geology of. Owen's Rep. 1859-60.

———Geology of. J. Collett's Rep. 1881.

Benedict, A. C. Geology of Wabash County. (See Elrod, M. N.)

———Petroleum in Indiana—S. S. Gorby (17th Annual Rep.) 1891.

Discusses briefly the history of Petroleum, its discovery in the United States; mentions the oil fields of United States, geological distribution; describes extent of bed, and oil field in Crawford and Wells counties.

Benton county, Geology of. Owens Rep. 1859-60.

———Geology of. M. Thompson's Rep. 1885-86.

Bessemer Iron, Manufacture of. E. T. Cox, 1876-77-78.

Beckwith, H. W., Indian names of water courses in the state. J. Collett's Rep. 1882; pp. 39-44.

Bigney, A. J., Preliminary notes on the geology of Dearborn county. Proc. Ind. Acad. Sci. pp. 66-67.

Notes the finding of mammoth and sloth remains.

Beachler, C. S. Keokuk group at Crawfordsville, Ind. Am. Geol., vol. II, pp. 407-412.

Describes the stratigraphic features of the Keokuk rocks and gives a list of the fossils of this locality.

———Notice of some new and remarkable forms of crinoidea from the Niagara limestone at St. Paul, Ind. Am. Geol., vol. IV, pp. 102-103.

———Corrected list of fossils found at Crawfordsville, Ind. (Keokuk.) Ind. Geology and Nat. Hist. Sur., 1888.

———List of fossils found at Crawfordsville, Ind. Am. Geol., Dec., 1888.

———List of fossils from Crawfordsville rock. M. Thompson's Rep. 1888.

———The rocks at St. Paul, Ind. Am. Geo., vol. VII, March 1891, p. 178.

———Abandoned Pleistocene river channel in Eastern Indiana. Proc. Am. Geol. Society, vol. IV, p. 62.

Blackford county. Gas. (See Phinney, Natural Gas in Indiana.)

Blatchley, W. S. A catalogue of the Butterflies known to occur in Ind. S. S. Gorby (17th annual Rep.) 1891, pp. 365-408.

Black Shale Fossils. Whitfield, 1874.

Blackford county, Geology of. Owen, 1859-60.

Boone county, Geology of. M. Thompson, Rep. 1885-86.

Boerner, C. G. Meteorology of Switzerland county. E. T. Cox Rep. 1872.

Borden, W. W. Scott county, Geology of. (Map.) Geo. Survey of Ind. 1874.

The geological formations are the drift, knobstone, black shale (Hamilton,) and coniferous limestone; list of fossils.

———Jefferson county. Geol. Survey Ind. 1874.

Geological formations were the Champlain, drift, black shale, coniferous limestone, Niagara, Clinton and Cincinnati; list of fossils.

———Rep. of Geol. Surv. of Clark and Floyd counties. E. T. Cox Rep. 1873, pp. 134-189.

Gives a brief account of the geological formations in the counties (Cin. group, Niagara, New Albany black shale, probably the equivalent of the Genesee, N. Y., and Knabe stone.

Boone county, Geology of. Owen's Rep. 1859-60.

Branner, J. O. Geol. Map Ind.

Brown county, Geology of. Owen's Rep. 1859-60; also Collett's Rep. 1874.

Brown, R. T. Geology of Hamilton and Madison counties. Collett's Rep. 1884.

———Fish culture in Indian. Collett's Rep. 1884.

———Geology of Hancock county. M. Thompson's Rep. 1885-86.

Discusses topography, drainage, nature of glacial drifts, archaeology.

———Geology of Morgan county. J. Collett's Rep. 1883, pp. 76-83.

Discusses drainage, topography, extent and thickness of Paleozoic formations, glacial phenomena; gives list of fossils and connected section of the county.

———Geology of Putnam county. J. Collett's Rep. 1881, pp. 89-125.

Describes the topography and stratigraphic geology; notes extent and character of the coal-seams. Refers briefly to building stone.

———Marion county, Geology and topographical survey of. J. Collett's Rep. 1882, pp. 79-69.

Discusses topography and stratigraphic features.

———Morgan county, Geology of. J. Collett's Rep. 1883, pp. 71-85.

Bradner, E. A partial catalogue of the flora of Steuben county. S. S. Gorby, 17th Annual Rep. 1891.

Building Stones. Thompson, 1888.

Byrkit, J. W. Catalogue and check-list of the trees and woody shrubs of America north of Mexico. E. T. Cox Rep. 1876-78, pp. 279-290.

Campbell, J. L. The Kankakee river and pure water for Northwestern Indiana and Chicago. Proc. Ind. Acad. Sci. 1891, pp. 70-73.

Describes the Kankakee channel and basin.

Carbonic (upper and lower). (See Stevenson, J. S.)

Carboniferous fossils. Owen's Rep.

Carroll county, Geology of. E. T. Cox's Rep. 1872: S. S. Gorly 17th Annual Rep. 1891.

———Geology of. R. Owen.

Cass county, Geology of. E. T. Cox's Rep. 1872; do Richard Owen.

Chalk beds of Indiana. M. Thompson's Rep. 1885-86.

Chamberlin, T. C. The Glacial boundary in Indiana and adjacent states. (Introduction) Bull. No. 58 U. S. G. S. 1890.

———Preliminary paper on the Terminal Moraine of the second Glacial Epoch. (Notice) A. J. S. III, vol. 28, p. 228, 1884. (From 3d Ann. Rep. of the Director of the U. S. G. S. 1881-82.)

———Hillocks of Angular Gravel and Disturbed Stratification, A. J. S. III, vol. 27, p. 370, 1884.

Discusses structural features of these deposits, nature and analysis of contents. (Sections of gravel bank from Tippecanoe county, Ind. A long list of contributions to this subject is appended.)

———The Bearing of some Recent Determinations and the Correlation of the Eastern and Western Terminal Moraines; A. J. S. III vol. 24, p. 93, 1882.

Cincinnati Arch. E. T. Cox's Geol. Rep. 1876-77-78; Am. Geol. vol. IV, pp. 6-20.

Cincinnati Group. A. J. S. III, vol. 17, p. 484. Question of nomenclature.

It was agreed by a committee from the Cincinnati Academy of Science that the term Cincinnati Group should not be retained.

Clark county, Geology of. E. T. Cox, Rep. 1873; also R. Owen.

Olay county, Geology of. Owen's Rep.

Clinton county, Geology of. Owen's Rep.

———Geology of. M. Thompson's Rep. 1885-86.

Collett, John. Geology of Brown county. Owen's Rep. 1859-60.

Indicates Bean Blossom ridge as the southern drift limit; considers the deep valleys due to glacial streams and the silt to indicate a former central post glacial lake; the gold of drift origin; formations, drift, geode beds and knob stone. Report accompanied by map.

———Geological report on Harrison and Crawford counties. E. T. Cox Rep. 1876-78, pp. 291-522.

Discusses the Stratigraphic geology (quaternary carbon, Dev. and Sil.) Gives lists of fossils from coalmeasures, and the subdivisions of subcarboniferous; also a list of fossil fish teeth (by J. S. Newberry); analyses of Harrison county meteorites; mention is also made of building stone, hydraulic cement, clays, mineral waters, oil (Crawford, county) caves, archæology.

———Geology of Warren county. E. T. Cox Rep. 1873, pp. 191–259.

Describes briefly the topographical features, quaternary deposits, extent and physical features of paleozoic formation (carboniferous and subcarboniferous). Mention is also made of coal, clays, gold and copper, building stone.

———Geology of Lawrence, Knox and Gibson counties. E. T. Cox Rep. 1873, pp. 260–430.

Describes the stratigraphy, gives numerous local sections and general connected sections of each county, exhibiting especially the relations of coal-seams. Mention is also made of fossils noted in the local sections, iron ore, building stone, clays, etc.; analysis of coals, archæological remains.

———Geol. Rep. of Vanderburg, Owen and Montgomery counties. E. T. Cox Rep. 1875, pp. 240–422.

Describes glacial deposits, physical features and extent of Geol. formations (Carbon Dev. sections) with occasional reference to fossils (Carbonif.); also details concerning development of coal, building stone, iron ore. A list of fossils from the Keokuk rock Crawfordsville is appended.

———Geology of southeast part of Clay county. E. T. Cox Rep. 1875, pp. 423–462.

Describes the glacial deposits, extent of paleozoic rocks (Carbonif.) as made out from borings.

———Geological reconnoissance of the coal-measure rocks of Putnam county. E. T. Cox Rep. 1875, pp. 463–468.

———Geological reconnoissance of Jasper, White, Carroll, Cass, Wabash, Miami, Howard, Lawrence, Knox and Gibson counties. E. T. Cox Rep. 1872, pp. 291–337.

———Second Annual Report of the Department of Statistics and Geology, 1888.

Agricultural and health statistics, pp. 5–368.

Geology of Indiana (with outlined Geol. map), pp. 375–384.

Brief outline of geographical extent of Geological formations by counties; describes oolitic limestone and Portland cement. Indiana coal versus Pittsburg coal.

The mammoth and mastodon remains in Indiana and Illinois. Archæology, pp. 384–396.

Geology of Putnam county, pp. 397–426.

Gives a connected section of the formations of the county (Quaternary, Carbonif., Subcarbonif.) and sections showing local details bearing on stratigraphy; fossils; tables of altitudes in Monroe and Putnam counties.

Geology of Monroe county, by G. K. Greene, pp. 426-499.

Synopsis of the Molluscan Fauna of Indiana, by Frederick Stein, pp. 453-467.

Fossils from Silurian, Devonians and subcarboniferous rocks of Indiana, by C. A. White (descriptions and plates), pp. 468-522.

—————Department of Geology and Natural History (eleventh annual report), 1881. 52 pl.; maps.

Statistics concerning the production of coal, and its cost, etc.; increase in production in the coal-producing states; also notes on clays (Kaolin) Lawrence county; tabulated statements indicating the capital, labor and appliances devoted to the quarrying of stone in Indiana, and the value of the product; brief outline of the extent of the oolitic limestone of Owen, Monroe, Washington, Harrison and Crawford counties and output of the various quarries; analysis, pp. 13-33.

Experiments upon the transverse strength and elasticity of building stones, by Thos. H. Johnson, pp. 34-47.

Tables of altitudes between Indianapolis and Cincinnati, on Cincinnati, Indianapolis, St. Louis & Chicago Railroad and other roads in S. Indiana, pp. 47-54.

Geology of Shelby county, pp. 55-88.

Describes topography; glacial drift (Collet's Glacial river); Stratigraphic Geology with numerous local sections; a list of fossils found in the county from Dev. (carboniferous) and Sil. (Niagara); notes on building stone, clays, etc.

Putnam county. Geology and Geography. R. T. Brown, pp. 89-125.

Delaware county, Geology of. A. J. Phinney, pp. 126-149.

Gives a general outline of the topography; Quaternary and Paleozoic Geology (Silurian), with list of fossils found in the county; notes on clays, agriculture, etc.

Bartholomew county, Geology of. Moses N. Elrod, pp. 150-213.

Descriptions of the species of fossils found in the Niagara group at Waldron, Ind. Prof. James Hall, pp. 214-345.

Fossils of the Indiana rocks. No. 2. C. A. White, pp. 347-375.

With description and plates (37-49).

VanCleave's Fossil Corals, pp. 376-410.

Description and plates (44-55).

—————Geology and Natural History Ind. (Twelfth Annual Report 1882, pp. 1-38.

In an introductory chapter the author gives observations on building stone, coal, glass, sand, clay, gas; United States surveys; growth of timber; Archaeology.

Archaeology: Indian names of water courses in the state of Indiana.

H. W. Beckwith, pp. 39-44.

Outline Geology of Ind. pp. 45-47.

Newton county Geological Survey, pp. 48-64.

Describes surface configuration, quaternary and paleozoic formations, accompanied by numerous sections.

Jasper county, Geological Survey of, pp. 65-78.

Describes recent and paleozoic geology, a list of fossils from two localities; notes on clay, iron, building stone, petroleum; table of altitudes in Jasper and Newton counties.

Marion county, Report of a Geological and Topographical Survey;
R. T. Brown, pp. 79-99.

Decatur county, Geology of. M. N. Elrod, pp. 100-152.

Jay county, Geology of. D. S. McCaslin, pp. 153-176.

Randolph county, Geology of. A. J. Phinney, pp. 177-195.

Catalogue of the flora of central-eastern Indiana by A. J. Phinney,
pp. 196-236.

Paleontology—Van Cleve's fossil corals, identified and compiled by
Dr. James Hall, pp. 239-270. Descriptions and plates.

Descriptions of fossil corals from the Niagara and upper Helderburg
groups of Ind. Prof. James Hall, pp. 271-375.

Diatoms of the waters of Ind. Rev. S. L. Curtis, pp. 377-384.

Geology and Natural History of Indiana 1883. (Thirteenth Annual Report). Part I Geology and Nat. Hist. Part II Paleontology. (Map.)

Report and work of the Geol. Department. Outlined Geology of Ind.; stone coals of Ind.; pp. 1-10.

Fuel values of coals. G. M. Livette, pp. 10-11.

Comparison of Ind. Block Coals with Ill. coals. E. T. Cox, pp. 35-37.

Posey county, Geology, pp. 45-70.

Describes the topography, alluvial and drift deposits and Pal. formations; gives general and local sections; notes fossils in a few sections. Economic Geology.

Morgan county, Geology of. R. T. Brown, pp. 71-85.

Rush county, Geology of. M. N. Elrod, pp. 86-115.

Johnson county, Geology of. D. S. McCaslin, pp. 116-137.

Grant county, Geology of A. J. Phinney, pp. 138-153.

Glossary of terms commonly used in Geological reports. W. T. S. Cornett, pp. 154-169.

Principles of Paleozoic Botany (Pt. II). Leo. Lesquereux, pp. 7-106.

Fossils of Indiana Rocks (No. 3). C. A. White.

Geology and Natural History of Ind. (Fourteenth Annual Re-

- port). Pt. I, Geology. Pt. II, Postpliocene Vertebrates of Ind. 1884.
 Outlined Geology of Ind., pp. 18-19.
 Hamilton and Madison counties, Geol. and Topographical Survey of.
 R. T. Brown, pp. 20-40.
 Fayette county, Geology of. M. N. Elrod, pp. 41-60.
 Union county, Geology of. M. N. Elrod, pp. 61-72.
 Drift deposits of Indiana. J. S. Newberry, pp. 85-98.
 Ohio river floods, pp. 99-102.
 Glossary of Terms used in Geol. Rep. pp. 103-109.
 Post pliocene Vertebrates of Ind. E. D. Cope and J. L. Wortman, pt.
 II pp. 3-41 (6 plates).
- Claypole, E. W.** Evidences from the Drift of Ohio, Indiana and Illinois in support of the preglacial origin of the basins of Lake Erie and Ontario, A. A. A. S., vol. 30, 1881, p. 147.
- Cope, E. D. and Wortman, J. L.** Postpliocene Vertebrates of Indiana. J. Collett's Rep. 1884, pp. 3-41. (6 plates.)
 Give a brief summary of some Geological facts bearing upon faunal relations in this period. (Quaternary). Describes nature of deposits in which mammalian remains are most frequently found; and some structural features of the chief groups of mammalia of quaternary times; also descriptions of a number of genera and species. Appendix, Genus Equus.
- Cope, E. D.** Faunas of Wyandotte and Mammoth Caves, E. T. Cox Rep. 1872.
 ————E. T. Cox, Geol. Rep. 1872.
 ————Faunas of Wyandotte Cave, E. T. Cox, Geol. Rep. 1876-78.
- Cox, E. T.** Second Rep. Geol. Surv. Ind. (Maps of counties) 1870.
 Gives general outline of quaternary deposits; emphasizes the importance of the coal in Indiana; gives analyses and sections from Sullivan, Daviess, Martin counties; general observations on coals of Knox, Dubois, Pike, Gibson, Warrick, Spencer, Perry, Vanderburg, and Posey counties. The Geol. formations and economic products and fossils are briefly described,
 Putnam and Vigo counties. Observations on mineral springs, coals; also paper by Dr. T. Sterry Hunt, oil wells of Terre Haute, pp. 118-163.
- **Western Coal-Measures of Ind.** pp. 164-187.
 Sullivan county, Geology of. J. Collett Rep. pp. 191-240.
 Jefferson county, Catalogue of the Flora of. A. H. Young, pp. 245-288.
- How to prepare and cook fish and other animal food. S. Collett's Rep. 1884.

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Describes topography, stratigraphy (Niagara), glacial river channels, Kames asars. Discusses the nature and extent of the terminal moraines of the second glacial epoch(?); the direction and extent of the boulder tract; archæology.

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—————The Natural Gas Fields of Indiana. U. S. Geol. Survey (11th Ann. Rep. of Director) 1889-90, pp. 617-742.

Under the heading "The Geological Structure of Indiana," the following topics are discussed:

- A. GENERAL STRUCTURE.** I. *Stratigraphy*—Giving a general section and brief outline of the extent, thickness and character of each rock-series—(map); also a table showing the total thickness of the drift as obtained from borings. II. *Altitude of the strata*—Views concerning the nature and extent of the Cincinnati arch; topography of Trenton limestone, as made out from well-borings. (Hypsographic map and cross-sections of Trenton limestone.) The hypothetical “Wabash arch” is briefly described. Prof. S. S. Gorby’s views, as contained in 15th Ann. Rep. Geol. and Nat. Hist of Indiana, are quoted.
- B. CONDITIONS OF GAS ACCUMULATION.** Sec. I. Conditions of rock structure. II. Conditions of rock texture.
- C. GAS PRESSURE AND MEASUREMENT.** Defines I. Static pressure. II. Open pressure. III. Retained pressure. IV. How to measure the amount (cubic feet) of gas yielded; gives tables showing capacity of wells.
- D. THE GAS FIELD AND THE BORINGS WITHIN IT.** I. The area yielding gas and oil. II. Records of borings within the main field reviewed by counties—(Blackford, Jay, Delaware, Randolph, Wayne, Madison, Grant, Howard, Tipton, Hamilton, Hancock, Marion, Miami, Wabash, Henry, Rush, Shelby, Decatur, Franklin, Dearborne, DeKalb) giving number of wells in each county and aggregate daily flow, etc.
- E. RECORD OF BORINGS OUTSIDE OF THE GAS FIELD.** Gives record of borings in the following counties: Union, Fayette, Bartholomew, Jennings, Jefferson, Clarke, Floyd, Harrison, Washington, Jackson, Johnson, Hendricks, Montgomery, Parke, Boone, Clinton, Carroll, White, Pulaski, Cass, Miami, Fulton, Porter, Lake, Laporte, St. Joseph, Marshall, Elkhart, Kosciusko, Whitley, Noble DeKalb, Allen, Wabash, Huntington, Wells and Adams.
- F. THE CARE OF GAS WELLS.**
- Pike county Coal.** Geology. Owen’s Rep. 1859–60; Cox 1872, do 1870; coal, J. Collett’s Rep. 1883. (See also Lesquereux.)
- Pitman’s Cave.** Description of. E. T. Cox Rep. 1872.
- Pocono.** (Group.) See J. J. Stevenson.
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- Posey county**, Geology of. Owen's Rep. 1859-60; E. T. Cox's Rep. 1875; do. (coal) J. Collett's Rep. 1883; (coal) see Lesquereux.
- Pulaski county**, Geology of. M. Thompson's Rep. 1888; do. R. Owen's Rep. 1859-60.
- Putnam county**, Geology of. R. Owen's Rep. 1859-60; E. T. Cox's Rep. 1870; E. T. Cox's Rep. 1875; J. Collett's Rep. 1880; do. 1881.
- University cave. J. Collett's Rep. 1884.
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Upper Carbonic.	{	Upper coal measures	{	Merome Sand stone.
			{	Upper coal measures.
		Middle coal measures	{	Lower coal measures.
Lower Carbonic.	{	Lower coal measures	{	Conglomerate or millstone.
			{	Grit.
		Greenbrier		Mountain Limestone.
		Pocono		Knobstone group in part.

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Indiana Building Stone, pp. 29-33.

Describes the qualities and extent of I. limestones in general II, oolitic limestones. III, sandstones.

Clays of Indiana, pp. 34-40.

Describes the nature, composition and mode of formation. Describes endianite (analysis) and compares it with analysis of clays from other countries.

Indiana Chalk-beds, pp. 41-43.

Describes the probable modes of formation; gives analysis (by Dr. Hurty) of samples from Lake Maxinkuckee and Kosciusco county.

Glacial deposits in Indiana, pp. 44-56.

Discusses Glaciers and their action; the glacial period, its extent and effect; descriptions of the drift deposits of Ind.; describes briefly sections and borings showing the interior of the drift deposits; also special features of the drift.

A Terminal Moraine in Central Indiana, pp. 57-60.

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Hancock county, Geology of. R. T. Brown, pp. 187-197.

Benton county, Geology of. S. S. Gorby, pp. 198-220.

Starke county, Geology of. W. H. Thompson, pp. 221-227.

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Natural Gas (what is it?) pp. 314.

Dissimilarities in composition, origin and accumulation; where found. "Surface signs" of its existence.

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- Partial Report of the Survey of the Western Division, including Sketches of Pulaski and White counties. M. Thompson's Rep. 1888, pp. 121-151.
Gives a general outline of the importance and kind of work which the survey is doing, viz: On gas developments, the tracing of morainic deposits; discusses also methods of drainage, formation of sand ridges, extent and nature of boulder drift, stratigraphy, gas (Pulaski) oil and iron; describes Tippecanoe river.
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SUGGESTIONS FOR THE BIOLOGICAL SURVEY.

By JOHN M. COULTER.

[ABSTRACT.]

In studying the flowering plants of any region, they are naturally divided into two categories, namely, (1) those that are indigenous, and (2) those that are introduced. Each one of these groups presents its own special problems in addition to those which are common to both. In the modern study of collected material it has become more and more evident that collectors ought to be trained. It is not sufficient to merely collect specimens

and give an approximate station, for biological investigation demands far more accurate and complete information. In the development of this work by the Indiana Biological Survey it would be well to issue a circular of instruction to collectors, calling their attention definitely to the proper methods of work. It would be well in the training of collectors to definitely divide their work for the season into two parts, namely, (1) the work of collecting all the plants of their district, together with suitable field notes, and (2) the detailed study of one or more of their most interesting plants. In work of this kind the following points must be especially made out:

(1.) *Mass distribution.* It is not sufficient to know that a plant is to be found in this or that part of the county, but it must be known where it occurs in the greatest abundance, and where in the least, and where not at all. The most convenient way to make observations of this kind is to use outline maps as large as possible of the county and upon this jot the occurrence of the plant observed. At the end of the season's work with one or two plants in this fashion, it will be discovered whether one is dealing with a comparatively even distribution throughout the county, or one that follows certain lines, or is restricted to certain localities. It is also easily seen whether the plants mass together in certain places and thin out in others.

(2.) *Topographical distribution.* Under this head is to be considered whether plants are inhabitants of uplands, swamps, prairies, etc. If they occur in all situations, which do they seem most to affect and in what respect are their characters modified by such changes of surface?

(3.) *Geological distribution.* This must take into consideration the soils upon which the plant grows. This part of the study is one that takes considerable knowledge of geology, for it is not always easy to tell the real nature of a soil, whether it is one *in situ*, or an artificial soil. For instance, the soil of the valley may not at all represent the disintegration of rocks that border the valley, but may have been transported from some distance. Great care must be taken in the determination of this drifted soil.

(4.) *The effect of man's presence.* Indiana may be new enough for something to be done in the way of discovering the distribution of most plants before man's invasion. The former distribution of plants, which are now confined to uncultivated areas, should be made out as far as possible. It should also be distinctly noted what effect the presence of man has had upon the occurrence of plants and what plants are able to adapt them-

selves to cultivated ground and what must confine themselves to strictly wild lands.

These facts should be noted not only in reference to the indigenous plants, but so far as they are applicable to introduced plants also. In reference to this latter class, the following points ought to be noted in addition: (1.) The time and circumstances of introduction so far as this can be ascertained. Many of our most notable weeds have long been under the observation of farmers and it is often possible to obtain from them valuable information as to the invasion of certain weeds. (2.) The vigor of introduced plants as compared with native plants ought always to be noted. This, of course, will involve an investigation as to what foreigners have been able to successfully make their way against what natives. (3.) Under the head of economic importance, the introduced plants are to be considered in relation to their injury to crops.

In Indiana not only should these general features of native and introduced plants be studied, but also certain special problems which belong to the state in its relation to other states and to the general topography of the Mississippi valley. The biological survey should have in view some of these special problems whose answer will probably contribute more to real botanical knowledge than the more general study of the state flora. Certain problems are here suggested to which many more may be added:

- (1.) The eastward extension of the prairie flora.
- (2.) The southern extension of the flora of the Great Lakes.
- (3.) The northern extension of the southern flora.
- (4.) The "Knob" flora.
- (5.) Flora of the limestone cliffs.
- (6.) The floras of various soils.

Under the last head Dr. Scovell suggested the "sand-bar flora" along large streams, and W. P. Shannon suggested the flora of the "white clays."

THE PHANEROGAMIC FLORA OF INDIANA.

By STANLEY COULTER.

The knowledge of the phanerogamic flora of Indiana while somewhat extended is far from satisfactory. Many excellent and some few noteworthy regional lists have been published as well as a provisional state catalogue, yet all leave much to be desired. It is unnecessary in this connection to deal in detail with the bibliography, since it is treated in an

earlier paper in this volume by Dr. Underwood. The following features however may be noted which will serve to show what is yet lacking for a complete knowledge of the phanerogamic flora of the state

All of these lists, with perhaps the exception of those of Dr. J. Schneck, and Dr. A. J. Phinney, are limited by *political* instead of *natural* boundaries. It is evident that while such limitation is popular and apparently in some cases necessary, it cannot result in publications which will furnish a basis for any useful generalizations without the most painstaking and arduous comparisons. Many apparent anomalies in distribution would doubtless be explained were the lists based upon natural divisions. In the exceptional lists referred to above, that of Dr. Schneck treats of the flora of the lower Wabash valley, thus necessarily including certain counties in Illinois as well as in Indiana, while that of Dr. Phinney refers to the Alpine region of Indiana and includes the four counties of Delaware, Wayne, Randolph and Jay. In both these lists, however, the political boundary is the final limitation. In the rather picturesque language of Prof. MacMillan—"Just as we should not attempt to interpret the laws governing the action of a constitutional convention by periodic examinations of a mercury-barometer, no more should we attempt to investigate the laws of plant distribution by adhering to the artificial lines which separate from adjacent commonwealths, or divide into counties or sections." The seven botanical regions indicated in Coulter and Thomson's *Origin of Indiana Flora* (vol. XIV., State Geol. Rep. pp. 256-7), while not perhaps strictly natural in all particulars will at least serve as a basis for present work, being established upon topographical and geological features.

A second feature to be noted in the lists mentioned above is, that in no single instance, so far as come to my knowledge, can the list be authenticated by herbarium specimens. In most cases the belief of the existence of a plant in any given locality rests solely upon the word of the collector. Those of us who know the necessity for critical study and careful comparison which obtains in so many species, recognize at once the unsatisfactory nature of such data. Given a sufficient paucity of specimens added to a desire to make as large a local list as possible and the factors are present for the introduction of many species "new to the state." I examined last year a bundle of seventeen plants "new to the state," and found eleven of them incorrectly determined. I do not mean to depreciate in the slightest the valuable lists already published, or to question the botanical knowledge and acumen of their authors. I only wish to empha-

size the fact, that in many forms an accurate determination is almost utterly impossible without opportunity for extended comparison. And the more extended the worker's experience in systematic research, the more convinced is he of this fact.

By an examination of the State Catalogue supplemented by lists, published and unpublished, most of which are in my hands, I estimate the phanerogamic flora of the state at between 1,300 and 1,400 species, excluding plainly evident "escapes" and the ferns and their allies, both of which are usually included in the totals furnished in the lists. Of this number I very much doubt if 900 species can be authenticated by all the herbaria of the state combined, including in this estimate all forms in private herbaria. This condition of affairs, if my estimate is correct, certainly shows the need of a careful and scientific revision of our state flora.

The criticism of existing catalogues is not made in a captious spirit, but for the sole purpose of showing how much is yet to be desired in the way of absolute facts before any satisfactory report of the phanerogamic flora can be made.

A critical examination of the various publications bearing upon this subject will indicate that many regions of the state have not been investigated in a way at all commensurate with their botanical importance. Of these regions I will only mention a few specifically: The "Knob" region, studied somewhat extensively by Dr. Clapp of New Albany, 1834-38, but since that time practically untouched. Many species in the State Catalogue rests solely upon the collections of Dr. Clapp, and can, I believe, in most cases be authenticated by herbarium specimens. This whole range of hills should be carefully investigated. The swamp and lake region in the northern central portion of the state has been almost untouched, if we except some few collections from the borders of prominent lakes and the researches of E. J. Hill in the district south of Chicago. To these might be added the tier of counties abutting upon Michigan and the western tier of counties from Vermillion northward. To one at all acquainted with the topography of Indiana it is evident that most promising fields still remain open for investigation.

The main purpose of a catalogue of the phanerogams of the state, is not the list, however complete and accurate this may be, but the data accompanying each form, which aid in determining the principles governing plant distribution, or serve, at least in some slight way, to resolve into simpler terms some of the complex factors of this problem.

An examination of the conditions affecting plant distribution, as has been admirably shown by F. V. Coville, U. S. Botanist (Botany of the Death Valley Expedition, pp. 10-19), from a utilitarian point of view, is of the greatest importance. In speaking especially of trees and shrubs he says: "They therefore stand as the most complete summation that can be attained of the natural light, heat, moisture, food, air and mechanic of any area: in other words, a sure index of the natural agricultural capacity of the soil upon which they grow. * * * It has been the practice of agriculturalists to gauge the capacity of soils, in regions new to the plow, by observations on rainfall, temperature, cloudiness, chemical composition of the soil, drainage, and many other phenomena, or by the even more laborious process of experimenting on every farm with each kind of cultivated product; ignoring the fact that this determination can be greatly hastened, cheapened, and authenticated by correlating the natural vegetation, especially that made up of the trees and shrubs, with that of other regions whose agricultural capacities are known." The list then is merely incidental, and its accompanying data furnish the only scientific or economic reasons for its preparation.

With this in mind it is evident how completely our existing local lists fail in furnishing facts from which any useful conclusion can be drawn. In most cases nothing beyond the words "common," "not rare," "abundant," "very rare," are given, and in some of the lists even these are omitted. In one list only, which at the moment I recall, are any facts bearing upon the *habitat* given. It is true that in exceptional forms, such as *Sullivantia Ohionis*, T. and G. or *Brachycharta cordata*, T. and G., valuable notes may occur, but the instances are exceptional.

That the proposed biological survey of the state may fully accomplish its purpose, the work upon the phanerogamic flora should in the future proceed under certain definite conditions and for the accomplishment of certain definite results. Primarily the data collected should be of such nature and in such form as to be readily correlated with similar work done in other states. That this may be accomplished it is necessary that similar data be collected and terms technically employed shall have an uniform meaning.

The words which have given rise to perhaps the greatest confusion by lack of uniformity in meaning, are the words: *range*, *locality*, *station* and *habitat*. I quote from F. V. Coville (Botany of Death Valley expedition, pp. 10), "The meanings that should logically be attached to these words are as follows:

“ *Range*—The region over which a type spontaneously grows.

“ *Locality*—The approximate geographic position of an individual specimen.

“ *Station*—The spot upon which the specimen has been collected or observed.

“ *Habitat*—The character of the place in which a type occurs.”

To illustrate the use of these terms Mr. Coville takes *Juncus cooperi* and the particular specimens of it collected under No. 204 of the report, tabulating the data as follows:

“ *Range*, in the lower Sonoran zone from Vegas Wash, Nevada, westward in California through the Amargosa valley, Death valley and Panamint valley, and again at Borrego Springs in the Colorado desert.

“ *Locality*, Death Valley, California.

“ *Station*, edge of salt marsh about 400 meters east of Bennett Wells, Death Valley, California.

“ *Habitat*, densely alkaline moist soil, apparently only that containing compounds of boracic acid.”

I have given this extract in full for the purpose of showing what a complete record is essential to the fullest knowledge of a flora, and also to emphasize the importance of “mass distribution” embraced under the head range, a fact rarely given by untrained collectors. As this series of definitions proceeds from the office of the Government Botanist they may be used in full assurance of their ready correlation. In the collection for the purposes of the proposed biological survey then, collectors should as far as possible, record in a concise and systematic manner, the following data: 1. Range, 2. Locality, 3. Station, 4. Habitat, 5. Local peculiarities, 6. Name, if known, 7. Date, 8. Abundance.

All notes should be kept in a note-book, the plant being known by a serial number, and the name of the collector.

Serial numbers should be carried forward from season to season. Thus if the last serial number of 1893 was 378, the first number of 1894 should be 379. Plants then are known by the number, the name of the collector and the date, as “2162 Jones 1893.” By this means plants are readily identified wherever they may be distributed, and provision made for future revision and correction.

Should a special collecting trip be made, the following additional notes should be recorded: 1. Itinerary, 2. Weather, daily, 3. Noteworthy plants observed but not collected.

In all cases as far as possible such ecological notes as are of value should be entered in the record. The note-book should also show under the proper serial number, the quantity of that form collected.

It is of course too much to expect in a voluntary work such as that proposed by the State Academy that every person who aids in the work will be able to keep typical records, for that is possible only in the case of specially trained collectors, but with a full knowledge of the facts needed each person contributing to this work can add some fact not definitely known concerning our state flora.

In a general way collectors should secure a sufficient quantity of any given form to admit of distribution into sets, a fact which should be especially observed in the case of rare plants or those of local distribution. This advice does not point in the direction of the extermination of such forms, for in all cases the collector, inferentially at least, is supposed to be free from any tendency to vandalism. They should also be careful in all cases to make *complete* specimens, a work that will necessitate some preliminary study of the different groups. Perhaps the most valuable sets of directions which we have for collectors are to be found in the publication of F. H. Knowlton of the Smithsonian Institute, and the collector's number of the Botanical Gazette (vol. - No. -). An examination of either of these publications will serve to assist the collector in his work and also add much to the value of his collection. Those intending to collect should notify the person in charge of the phanerogamic flora, in order that he may suggest to them special points for investigation and study. Through these special studies much of value may be accomplished.

It is evident from the preceding pages that in my opinion, the work, as far at least as the phanerogams are concerned, should be placed in the hands of one person. He should assign special groups for determination to those specially fitted for the work and should indicate as far as possible the regional problems for investigation. It would, under such conditions, be possible to effect such co-ordination of work that the results would be not only of scientific but of economic value.

Material should be collected, so that complete and authenticated sets could be distributed to each college maintaining a herbarium, and from which duplicates of special noteworthy forms could be furnished to the specialists of the country. It should be a great, working herbarium, thoroughly representative of the state, and sufficient for all the demands that would naturally be made upon such a collection.

It was my purpose to consider in this paper the various collections of the state, private as well as those owned by the various colleges, but the necessary data are not yet in my possession. I trust however at the spring meeting of the Academy to present a tabulated statement covering these points.

This paper, submitted to the Academy at the request of the directors of the state biological survey, is merely an expression of my own personal views, the exact form which this work may take lying wholly in their hands.

THE RELATIONS OF THE HIGH SCHOOLS OF INDIANA TO THE PROPOSED BIOLOGICAL SURVEY.

By W. S. BLATCHLEY.

In my opinion the high schools of the state could, in the presence of the proper conditions, be made a most important factor in the prosecution of the proposed survey, and could themselves derive much benefit from it. But, in probably the majority of cases, the conditions are lacking, and before they can be brought about I am afraid the survey will have long since been completed.

It is to the teacher of biology, if to any one in the faculty of the high school, to whom the survey must look for aid. He, or she, alone of the faculty, is supposed to be interested in birds, bugs and flowers to such an extent that they can readily instill in the minds of their pupils that desire to know more of the secrets of nature and of the life history of her varied objects which will cause those pupils to be on somewhat intimate terms with their local fauna and flora, and so be able to note to some degree the more rare and interesting forms of animal and plant life about them, to be able to record the abundance of these forms, their local distribution and the causes thereof, in short all facts which may afterwards be of aid to the directors of this survey and their assistants.

Only teachers who are themselves enthused with the subject can beget the necessary enthusiasm in their pupils, and it is to such teachers as leaders, therefore, to whom the survey must look for aid.

Let us consider then the high school biology teachers of the state as a class, and see whether much should be expected of them by the survey.

We may classify them roughly into three great groups, which, for want of better terms, I shall designate as "fossils," "special microscopists," and "all around biologists." In the brief time at my command I have not been able to gather the statistics concerning these three groups, but Prof. B. W. Evermann, in 1891, wrote to the different high schools of the state for information on this subject and the answers he received disclosed the fact that to the class I designate as "fossils" belongs as yet a very large number, rather let us say a large majority of the high school biology teachers of the state: but, and let us be devoutly thankful, their number is steadily decreasing.

They teach Steele's Zoology by rote. They never see or use a specimen unless it be a horned toad from Texas or a dried sea urchin from Buzard's Bay. They have no zoological works of reference except the pictures in the back of Webster's unabridged dictionary. They spend days in descanting with their classes upon such important biological facts as the "comparative length of the tail in the different species of monkeys;" or, as in a case gone down into history from one of the leading high schools of the state, "on which foot of the Ornithorhyncus does the webbing extend past the toes?" That I am not using hyperbole in speaking of their teaching, let me read you verbatim from their standard author, Steele, the sole fact which he gives concerning the leading family of one of the seven great orders of insects. Here it is:

ACRIDIDÆ.

"The grasshoppers or locusts of the western states belong to this family. They come in such multitudes as to give the sunlight the yellow tinge of dense smoke and to eat a large field of grain in an hour."

And yet, as proven conclusively by Prof. Evermann, the great majority of the high schools of the state, where zoology is taught, use Steele's book alone and teach such bosh by rote. What a travesty upon nature teaching! What a blot upon our boasted advanced scientific methods!

As, yielding to the demands of the times, the "fossil" steps aside, he often makes way for the "special microscopist." The latter is a product of the one sided development theory at present so conspicuous in some of our higher institutions of learning. He is an evolved histological and embryological specialist with a B. S. after his name, and a summer or two's experience at some seaside laboratory to give him added prestige. He is an expert in the use of the microscope and microtome. He knows every detail concerning the embryology of the sea-squid and the develop-

ment of the amphioxus, but he don't know a jumping mouse from a long-tailed shrew, an oriole from a cat bird, nor a Hessian fly from a chinch bug. The only field of nature which he has ever explored, or which he deems worthy of exploration, is the field beneath the lenses of his microscope.

When he assumes the biological chair he does so for two reasons; first, to replenish his exchequer; second, to use his position as a stepping stone to a higher one, where his methods are in vogue.

He finds on entering the high school no equipments for teaching zoology, no collection except a worm-eaten, dried sea urchin and a half rotten, alcoholic horned toad, no library except a worn copy of Steele's zoology. He appeals to the school board for aid. Their belief in the potency of his sheep skin and other credentials cause them to allow him \$300 for supplies. Two-thirds of this he expends for compound microscopes, a microtome and reagents: one-sixth of it he sends to a marine supply house for sea urchins, star fish and amphioxus, and with the remainder he purchases a few standard reference works on embryology and morphology: and then settles down to teach his pupils of fourteen and fifteen years of age in the high school, the same facts according to the same methods which he learned in the great universities where he received his special training.

His pupils bring in for a time birds, reptiles and insects from their native heath, but their instructor can tell the youthful collectors nothing of the habits, life history, or classification of their specimens. Their natural desire for collecting and observation, which, with a little encouragement, would soon have resulted in much good both for themselves and for the high school collection, is soon chilled.

They cease to notice the animals and plants about them, and in a month or two settle down under the teacher's guidance and study, for a year, sections one-three thousandth of an inch thick of some half dozen marine forms, and perhaps, if they know where to find them, of the eggs or tadpoles of a frog or salamander.

At the end of the year they can talk smatteringly of ectoderms, blastospheres, actinial filaments and calyco blasts. They can make fair diagrams of the sections they have studied, but they know little of morphology, less of adaptation and correlation of organs, and absolutely nothing of the classification of animals.

They graduate from the high school and go out into the world. One

out of ten goes to a normal school, college or university. One out of a hundred of these makes zoology a specialty and perhaps follows in the footsteps of his former preceptor. The other ninety-nine become artisans, merchants, professional men or farmers; or, if of the gentler sex, the wives of the above. They go through life meeting daily nature's objects on every hand, yet seeing them not; surrounded by problems interesting and instructive, yet knowing nothing of the problems themselves or of the method of their solution.

They see no order, no relations among the animals and plants around them. Knowing nothing of classification, they are unable to find the name of any plant or animal, which, from some conspicuous external character, attracts their attention. If they should happen upon Kirtland's warbler they would never know but what it was the common "yellow-rump."

Taking all these facts into consideration it is obvious that the proposed survey can expect little or nothing from those high schools where "fossils" or "special microscopists" are at the head of the work in biology. In such schools the "proper conditions" are lacking.

The "all around biologist," if I may term him such, at times succeeds the "fossil." With the money received from the school board, usually a much smaller sum than that secured by the "special microscopist," he purchases one or two compound microscopes, a number of sets of dissecting tools, ten or fifteen gallons of alcohol, some fruit jars, etc., and expends the remainder for general reference works on biology, especially those treating of the morphology, physiology and systematic position of the more common forms of life. These works of reference are in an ascending series, beginning with the more simple, as Huxley and Martin's *Biology*, Huxley's "Crayfish," Hyatt's "Insecta," etc., and advancing to the more complex.

The instructor begins his teaching at the very bottom of the work, with a few simple talks, illustrated by common specimens picked up in the neighborhood, in which he develops the distinctions between organic and inorganic objects, and between plants and animals. A week or two is then spent upon the elements of histology, explaining, by the use of typical sections, the parts of a cell, cell multiplication and the structure of the primary animal tissues. The pupil is then put to work for himself, with Colton's or some similar zoology in hand, upon a grasshopper as a type of arthropoda and insects. Three weeks are spent upon this, and a week each upon typical examples of the other six orders of insects.

After a careful examination of the structure of each type, including accurate drawings of the principal organs of each, and the reasoning, led by skillful questions put by the teacher, from structure to function, the teacher himself gives for one to two days a talk upon the systematic position of the common representatives of the order, illustrating the remarks by fifteen or twenty examples from the fauna of the home county. Questions of adaptation, local distribution and the causes thereof, come up in such talks and are discussed by both pupil and teacher.

After the insects comes a study of a mussel and snail as types of mollusks, and a crayfish as a type of crustaceans. In this way the first half year is spent upon invertebrate forms of life.

After the pupils begin to understand something of the scope of the work a certain group of animals belonging to the county, such as beetles, crickets, snails, batrachians or mammals, is assigned to each one to be worked up during the year outside of school hours. As full a collection as possible of the group assigned is to be made by the pupil. Full notes are kept on local habitat, distribution and the causes thereof, habits, food and so on, these notes to be incorporated into a paper to be read before the class at the end of the year, which paper, together with the collection, shall be graded as part of the year's work.

The teacher goes with the class into the field on a number of occasions in fall and spring, helps each collect in his or her special line, instructs them in the preparation of specimens for a permanent cabinet, cites them to works of reference on their respective groups, etc. All duplicates collected are deposited in the high school collection which thus increases rapidly in size. The "all around biologist" has for his school room motto the following: "He is a good naturalist who knows his own parish thoroughly."

In the work proper the second half of the year is devoted to vertebrates, modifying this work so that after dissecting a type of each class of vertebrates the pupil is required to draw up an accurate description of each of three or four members of the class and from the description determine the systematic position of each by the aid of Jordan's "Manual of Vertebrates."

Following this course of instruction the average pupil, at the end of the year's work in zoology, will have something of a knowledge of the relationship existing between animals and plants and between the different groups of animals themselves.

He will have a knowledge of the gross anatomy of the principal organs of at least a type mollusk, crustacean, insect, fish, reptile, bird and mammal. He will be able to reason from structure to function and to understand at least the principles of adaptation and correlation. He will have gained a certain power of comparison and the power of grasping the leading distinctions between the principal groups of animals. He will be able to go into the field, observe, record and collect the animals of any group in which he may be especially interested. He will be able to take a manual and find for himself the name and systematic position of any animal which he will be likely to meet in his after life.

Morphology, physiology and systematic zoology are then, in my opinion, the three divisions of zoology which should be particularly dwelt upon in high school work; while embryology, advanced histology and microscopic technique should be relegated to the higher institutions of learning.

The "all around biologist" at the head of the work in the high school, constitutes, then, the "proper conditions" to which I referred at the beginning of this paper. Where such conditions exist the biological survey of the state can reasonably expect much aid. There, collections of the local fauna and flora have been made, and can be studied by the specialists on the survey who are interested in them.

There, observers, former pupils or present advanced pupils, can be found, who, when fully informed of the objects of the survey, will be both willing and able to observe, collect and record for the survey. Due credit should be given in all publications of the survey to the high school and to such individual collections. As a further reward, after the work is practically finished, typical collections of duplicate mollusks, insects, fishes, etc., from different parts of the state could be presented to those high schools which have aided materially in the survey. Moreover, copies of all publications of the survey could be furnished them to be added to their reference library. In this way the future biological work of the high school would be more easy and more valuable, and thus both school and survey would derive a mutual benefit from the work in hand.

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THE SPECIAL SENSES OF PLANTS.

BY J. C. ARTHUR.

We are told by Louise Michel, a woman of remarkable, if somewhat eccentric intellectual powers, that when in Australia sitting at her window one day her attention was attracted by the slow but regular movements of a climbing plant. Its long free end swept slowly around, like an outstretched arm reaching for something to cling to. Does it feel? is it moving in response to some inward desire? are the questions she asked herself; and thought it not improbable that an affirmative answer might be truthfully given. The last number of *Meehan's Monthly*, a journal of considerable scientific pretention, gives editorial endorsement to essentially the same views. To what extent plants have senses or sensibility is a question that thoughtful people have asked, and will continue to ask, and is indeed a subject well worthy of attention.

In the days of Aristotle plants as well as animals were distinguished from the inanimate world by the possession of a soul, to which the characteristic features of the organism as a living object, were ascribed. Aristotle's theory of a soul in plants was ably expounded by the distinguished Italian scholar, Cesalpino, in the sixteenth century. He entered into lengthy arguments regarding the seat of the soul, and concluded that it must reside in the pith, particularly in certain portions of it. With a philosophy of this nature there was nothing incongruous in the popular notion of the times that some plants were endowed with properties akin to human. Some exercised wonderful spells over persons coming into their presence, and some would "shriek like mandrakes torn out of the earth, that living mortals hearing them, run mad," as Shakespeare puts it.

This doctrine of a biologic soul, which was, however, more materialistic than spiritualistic in its application, helped to shape botanical philosophy from the time of Aristotle and earlier down to the middle of the eighteenth century, having had much to do even with determining the views of Linnaeus. In its strictest form, as expounded by Cesalpino, the doctrine is

not particularly startling even at the present day, for he taught that plants possess "only that kind of soul, by which they are nourished, grow, and produce their like," the capacity for sensation and movement being denied to them. If I mistake not, the popular notion of plants in our own day does not differ essentially from this scholastic philosophy of several centuries ago.

The second period of development of the ideas respecting sensation in plants, or we might better say the want of sensation in plants, was opened by the famous dictum of Linnæus that, "minerals grow, plants grow and move, animals grow, move and feel." Linnæus' great prominence as a systematist gave to this dogma special force, although in reality it was but a slight modification of the teaching of Cesalpino, already referred to, and of his successor Jung. Much of the controlling opinion of the greatest philosophical botanists down to the present century can be traced back to these two scholastics. Jung was a contemporary of Kepler, Galileo and Descartes, and dominated botanical thought in Germany, as Cesalpino had done in Italy. He expressed his view in the sentence: "*Planta est corpus vivens non sentiens.*"

The force of Linnæus' aphorism was more in its form than in its newness, in spite of the fact that he ascribed motion to plants, for it seemed to separate nature into three sharply delimited kingdoms: mineral, vegetable and animal. Botanists and zoologists have from that time to within a few years of the present been fruitlessly attempting to find infallible characters for distinguishing animals and plants. The discovery of protoplasm in 1846, of its identity in the animal and vegetable organism somewhat later, and the publication of the origin of species in 1859, brought an end to the old order of things, gave rational unity to the organic world, founded a science of biology, and converted the scholastic method of studying nature into the dynamic method. At the present time the motto of the botanist is "the study of plants as living things," and by acting upon it the science has been redeemed from the lethargic state of being "a chronicle of the dead," as Julian Hawthorne characterises it, into a subject of immediate and vital interest.

The fact that plants possess sensibility, or as the text-books now say, irritability, was made conspicuous and put beyond all doubt, even with the unlearned, when the sensitive plant (*Mimosa pudica*) was discovered in America and taken to the gardens of Europe. A plant of such easy culture in either the garden or the conservatory, and possessing such wonderful

sensitiveness to touch, attracted general attention. In 1848 Brücke's memoir upon the sensitive plant appeared. It was a model for thoroughness, for ingenious methods, and lucid deduction. From this clear and unequivocal starting point it was comparatively easy to pass to the less obvious forms of irritability, and since then many kinds of reaction to stimulation in plants have been brought to light and made the subjects of investigation.

But admitting that plants have sensibility, that is, are capable of responding to stimuli, is far from admitting that they have senses. Active protoplasm is always sensitive to some form of stimulation. If a bit of fresh striated muscle, from the leg of a frog for instance, be struck, or pricked with a needle, or shocked with a current of electricity, it will respond by contraction; and so will the protoplasm in the cells of an onion or other plant. Contractility is a universal property of living matter, although different cells of the vegetable and animal structure display it in varying intensity. There is, however much disparity between contractility and sensation. Whether this disparity is real, that is whether there is actual discontinuity, or whether it is only seeming, being the expression of extremes, is an important inquiry.

If we approach the subject from the opposite direction, we shall have a very different point of view. There is no way of securing a just conception of the extent and relations of an object, as of a house or a tree, like viewing it from different sides. To consider the contraction of the muscles of the arm when the hand has touched an uncomfortably hot surface, is to study the physiology of the movement, but to consider the mental disturbance produced by the perception of heat, is to take a very different point of view and study its psychological relations. One is the objective and the other the subjective method; both have advantages. But both methods should lead to a unity of conception; and this should be a more complete conception, than either method could give pursued by itself; just as viewing a house from the east side and from the west, is better than viewing it from one side alone. So far as I am aware, no writer has presented the psychological side (if the expression may be used) of the movements of plants, although the foremost investigators, Darwin, Sachs and Frank, make the presentation of their physiological studies attractive by use of psychological expressions. Darwin, in his work on climbing plants, describes the behavior of a plant, which failed to secure a hold upon a tall stick placed at a certain distance, the free end of the twiner,

as it swept around in a circle, each time sliding past the support after being pressed against it for some time; and adds that "this movement of the shoot had a very odd appearance, as if it were disgusted with its failure, but was resolved to try again." In summing up his studies on the root tip in his volume on the power of movement in plants, the same author states that the tip of the root "acts like the brain of one of the lower animals." But we are not supposed to interpret these expressions to mean that a climbing plant has feeling or that a root thinks.

As our knowledge of nature is dependent primarily upon our powers of cognition, it is not strange that students of subjective phenomena should, like Descartes and Leibnitz, in the earlier days of the science of mind, and Hegel and Locke in more recent times, refuse to entertain any connection between mind and matter, except that of association. With the gradual unfolding of a knowledge of physiology, and the adoption of its revelations and methods, a gradual extension, overlapping and fusion of the spiritual and material, the subjective and objective, manifestations of living nature have taken place. But if we examine the writings of Bain, Carpenter or Herbert Spencer, of the English school, or Herbart, Lotze or Wundt, of the German school, or other representatives of the present liberal movement, we shall find that activity has only been transferred from the cerebral hemispheres to the ramification of the nerves, and from a search for the seat of consciousness to a study of the transmission of impulses. But it is to be remembered that the brain and nerves are the telegraphic lines and relay stations for communicating intelligence of the condition of the outside world to the sentient organism, and furthermore that many of the lower animals and all the world of plants are without nerves; they are like society before the advent of the telegraph, telephone and postal system. This large part of animate nature is, for the most part, ignored by the psychologists, and treated by the physiologists only objectively. In fact, subjective, that is obverse, physiology is in need of devotees.

There is great diversity in the use of the terms sensitiveness, sensibility and sensation, when applied outside the domain of human psychology. We are inclined to accept for our present purpose the usage adopted by Maudsley, who makes the term "sensibility" generic, and divides it into irritability, reflex action, sensorial action, and idealistic perception. In this classification organisms without nerves, which are the only ones we are now interested in, are only capable of sensations due to irritability.

An eminent Bavarian botanist, Nägeli, has philosophised upon the subject of universal sentience. "In the higher animals," he says, "sensation is distinctly present in the movements consequent upon irritation. We must therefore credit the lower animals with it as well, and we have no reason to deny it in the case of plants and inorganic bodies." This claim for continuity is attractive, but is much too sweeping, and not sufficiently logical. No good purpose can be subserved by crediting minerals with feeling, which we find Nägeli has done because their molecules exhibit the attracting and repelling forces of chemical affinity. His assignment of sensation to plants rests upon no better basis. Probably no author has given more earnest attention and study to this subject than G. H. Lewes, the distinguished English psychologist. He has told us, in his volume on the object, scope and method in the study of psychology, that he was at one time fascinated with the idea of a comparative psychology, which should begin with simple organisms and thereby gain in strength of interpretation upon reaching man. He began to collect materials with this view, but afterward abandoned the project as impracticable. We may parenthetically remark that his failure to secure material in this way to interpret human action does not disprove the feasibility and usefulness of a comparative psychology in which man shall receive only the share of prominence due him as a member of the organic series. However, his studies made possible a far clearer insight into the distribution of sensibility in organisms. One of his illustrations, very familiar to every laboratory student, is especially pertinent. He says: "Touch the eye of a frog, and there is at once the response of a reflex closure of the eyelid. Touch the hairs of a Venus fly-trap (*Dionæa muscipula*), and there is at once the response of a reflex closure of the leaf. Confine the frog and the dionæa under a glass shade, and place there a sponge, over which ether has been sprinkled. Both plant and animal breathe this air in which there is vapor of ether, and as this vapor penetrates to their tissues we observe a gradual cessation of all sensibility; first the reflex actions cease, then the irritability of the particular tissues ceases. Stupor has supervened for both. Now remove the glass shade; the vapor dissipates, the fresh air penetrates to the tissues in exchange for the vitiated air, and both frog and dionæa slowly recover their sensibility." From this experiment he justly concludes "that the animal and plant organisms have with their common structure common properties, and that if we call one of these properties sensibility in the animal, we must call it thus in the plant."

This, and many other equally satisfactory observations, appear to lay so good a foundation for a proper appreciation of the scope of sensibility that we are surprised and disheartened to find him finally in a hopeless muddle of plants, monads and molecules, and when he has affirmed that "sensibility stands for the objective phenomena exhibited by an organism under stimulation," he must needs add, to save himself from possible entanglement, "or, more definitely, for the reaction of a neuromuscular mechanism." No great progress can be hoped for in the study of nerveless organisms by a constant comparison of their behavior with that of organisms with nerves and nerve centers. There is need of a different method.

This review of the present state of knowledge regarding the relations of sensibility in plants and animals shows an astonishing absence of agreement and a total lack of a rational basis. The confusion, it seems to me, is due to a disregard of the conditions under which sensibility has been developed in the two divisions of the organic world. Knowing that irritability is a fundamental property of all living matter, let us ask ourselves what advantages the animal or plant could secure by its special development. That is, given this universal property of organisms, how could it be developed into special senses? It is unquestionable that the paramount necessity of the organism is self-preservation. To secure food, to keep out of harm's way, to obtain the proper supply of air, moisture and heat, may be considered the fundamental necessities of every organism, whether man or monad, tree or microbe. Considering for the present only the higher organisms, we note that, if an animal desires food, its sight and scent aid in searching for it, if in danger its sight and hearing enable it to escape, when food is obtained taste and smell indicate whether it is to be eaten or rejected, while touch gives a variety of sensations relating to food, bodily comfort and protection. Our present purpose does not require any mention of intellectual sensations. All the lower animals, down to the simplest unicellular forms, "the little lumps of protoplasm" described by Hæckel, possess one or more of these senses, and some animals may possibly possess other kinds in addition. The point to be especially noted here is that each individual animal (with a few exceptions among the lowest forms) has the power to flee when its senses indicate danger, or to advance when desirous of food, or to seek another place if the present one is too wet or too dry, too hot or too cold.

Let us examine plants in a parallel way. If they need food do they have sight and scent to aid them in searching for it? No, because they are

firmly attached to one spot; roaming about is impossible, and to see and smell would be useless. If they were in bodily danger, no acuteness of sight or hearing would avail them in the least. Were the aspen quaking through fear of some horrible calamity, it could not move an inch out of the path of destruction. Again, plants take no solid food, and have no use for a sense of taste. In short, animals are endowed with a set of senses which would be practically useless to plants, from the fact that the latter are, with very few exceptions, fixed instead of being locomotive organisms.

But are there no movements within the power of a fixed organism that can be brought about by the action of stimuli, which may aid in self-preservation or improving the conditions of existence? I think that a little reflection will show that there are; and if we can find that plants have developed special mechanism in connection with a superior localized sensitiveness to enable them to take advantage of the conditions of their existence, we shall have demonstrated the possession of special senses.

There is no requirement for plants more universal or more necessary than that their roots should penetrate the soil and their foliage be spread to the air. Yet the root or shoot has no more power to deviate from extension in a straight line unless acted on by some external force, than a cannon ball or other moving body has to vary *its* course from a straight line. If a seed in germinating should lie in such a position that the roots point upward and the stem downward, some device is needed by which the plantlet may readjust itself, by either turning over bodily, or changing the direction of its growing parts. As everyone knows the latter alternative is adopted, and the roots bend down and penetrate the earth, while the stem bends up and lifts its foliage into the air. It is so apparently a matter of course that stems grow up and roots grow down, that we may never have given a thought to an explanation of the process. Even botanists have only recently felt the full necessity for accounting for the fact, as it has been only a decade since Vöchting announced his theory of rectipetality, or the inherent tendency of growing organs to extend in a straight line unless acted upon by outside forces.

There is only one force known that acts uniformly in the direction of the center of the earth, that is gravity; and it was the genius of Andrew Knight, an Englishman, to demonstrate as long ago as 1806, that this force does furnish the directive influence in securing verticality to plants. He grew plants on revolving wheels, and found that they responded to centrifugal force, and that when the wheel was placed horizontally and re-

volved at a speed that made the centrifugal force equal that of gravity, both roots and stems grew obliquely, taking the position of a resultant of the two forces, that is, of forty-five degrees to the vertical.

But this discovery of Knight's was not very fruitful, for no one could tell how gravity could produce the effect ascribed to it. If it pulled the root down, why did it push the stem up? The stem is as heavy as the root, why are not both attracted toward the center of the earth? It was a curious paradox to say that the same force acted now one way and now exactly the reverse on different parts of the same plant; as if pulling and pushing were the same thing. It was supposed that gravity acted upon the root as it does upon a mass of taffy candy, drawing it downward. But Sachs showed in 1873 that the root of a bean fixed horizontally over mercury could penetrate the mercury in assuming a vertical position. As mercury is thirteen and a half times as heavy as water, or the tissue of a young root, it is evident that far more force was expended in penetrating the mercury than could have been derived from the physical action of gravity, that is, from the simple weight of the root. The experiment has since been tried in another and more obvious way by harnessing a root tip lying horizontal to a weight suspended over a pulley, the weight being raised as the root bends downward in response to gravity. From these experiments we must conclude that gravity does not act physically but physiologically to induce the curvature, that is, it acts as a stimulus. It is a small spark that fires the gun. The same spark will fire a pistol or a cannon, the result depending solely upon the amount and arrangement of the explosive material. So in the root, if there is the proper mechanism and storage of force, gravity will release this force and cause the bending, the amount of work done being enormously out of proportion to the initial expenditure of energy. But when the bending takes place, will it be upward or downward? If it were a purely mechanical device, it is evident that by knowing the structure of the organ, one could predict the direction of movement under stimulation. But we shall have to look beyond and above simply mechanical laws for an explanation. The wooden horse could not have destroyed Troy without a guiding principle within more intelligent and effective than mechanical force.

But in attempting to solve the problem, do not let us attempt too much. Let us accept such an explanation as we would consider satisfactory in case of a similar problem regarding the behavior of an animal. To see with our eyes and not with our fingers, to hear only with our ears, taste

with the tongue, and so on for the other senses, seems like a matter of course. But to explain why the nerves of the eye are only sensitive to light, of the ear to sound, of the fingers to impact and temperature, and so on, there being no structural differences detectable between the various sets of nerves that bring about such diverse results, we are content to say that it is due to a specialization of sensibility. The nerves at the tips of the fingers are more sensitive to touch than those at the back of the hand. The fingers have nerves that respond when stimulated by heat, but in the eye the nerves will not respond to heat but will respond to light. We do not marvel at this, it is everyday knowledge. We put it in scientific language by saying that irritability, a universal property of living matter, has been developed and specialized in different organs so as to respond differently to different stimulation. Fundamentally there is agreement, but the results of specialization are diverse. In the plant the root has a special sensitiveness to gravity, which is manifested by causing it to bend earthward, the stem possesses a sensitiveness which causes it to bend skyward. To meet its conditions of existence the plant has developed a special sense, that of geotropism, by which it is enabled to take advantage of the directive influence of gravity to place and keep itself upright in the world. It has a sense which animals, with their freedom of movement, appear to be nearly or entirely without. Animals assume an upright position, not in response to a direct gravity sense, but to secure the most comfortable adjustment of the weight of the parts of the body. Uprightness is a question of weight in the animal, a question of special sense in the plant.

It may be objected to this designation of the gravity sense in plants as a special rather than a general sense, that it is diffused throughout the plant and not confined to particular, specialized organs. This objection has some show of validity, but is not formidable. The apparent difference is not fundamental, but necessitated by certain structural features. Animals have a jointed, or wholly mobile body. In the jointed forms, and often in the others, there is an arrangement of muscles, with a communication of nerves with which to bring about movement as a response to stimulation. Plants, on the contrary, have a rigid body; the sensitive protoplasm being divided into innumerable minute particles, each little mass separated from its neighbors by thick, nearly rigid walls of wood or cellulose. It used to be a favorite illustration to say that a plant was like a great prison, with innumerable cells separated by thick walls, each cell occupied

by a prisoner. Although the individual prisoners may be strong men, and be in a frenzied state of activity, beating the sides of rooms, yet a spectator looking at the outside of the prison would see no movement of the walls, no evidence of life. With the discovery of continuity of protoplasm between plant cells, an English discovery of 1882, we have learned that to have our illustration really accurate, we should suppose all the cells of the prison to be connected by telephone. We must furthermore provide towers, with walls that are thinner and of flexible material. Now, if an alarm is given, all the prisoners being apprised at once, or nearly so, act in concert. The spectator on the outside sees no movement in the thick-walled part of the structure, but he sees the towers sway. We must further suppose that the men in the thick-walled cells, finding their efforts are useless, no longer make any response when the alarm is given, while those in the thin-walled cells, finding their efforts rewarded, become constantly more active and learn how to combine their efforts for greater efficiency.

The application to the plant is obvious. Although the force which a plant can exert amounts to several atmospheres, it is only in the young tender portions, usually at the ends of the branches of the stem and root, that this force can be successfully applied to secure movement of the whole organ. It therefore comes about that movement in plants is oftenest associated with growth. This arrangement permits each root tip and growing stem to have its own kind and degree of sensitiveness. Thus we find by experiment that while the first root which starts from a seed, the tap root, is sensitive to gravity in such a way that it places itself parallel to to the direction of the impinging force and points directly downward, the secondary roots, which branch from it, are sensitive after a different fashion, and instead of growing parallel to the force, grow at an angle to it, the exact angle being different for different kinds of plants. The tertiary roots, or next set of branches, are usually very little sensitive to gravity, or if they are sensitive they assume a nearly horizontal position. The stems react in a similar way, except that the general direction is upward instead of downward, and in consequence of the diversity of sensitiveness of the primary and secondary shoots, the branches are spread out to the air and light, imparting to each species of the tree and herb its characteristic appearance.

But if there is no nerve-like communication between one root tip and another, or between one stem end and another, there is sometimes a dis-

ting transmission of impulse from the cells receiving the stimulation to the cells a short distance away where the movement is consummated. Thus, in the tip of the primary root Darwin found that only the cells at the very tip were sensitive. If so small a piece as the twentieth of an inch be removed from the end of the root by cutting or burning, all power of movement is lost. This remarkable localization has been denied by Sachs and Detlefsen, who characterize Darwin's claim as sensational, but the fact has quite recently been fully verified by Wiesner, who finds that if the root is weakly sensitive, the seat of irritability coincides with the zone of most rapid growth, but if highly sensitive, it will be at a distance.

To sum up the characteristics of the gravity sense: It is localized in or near the ends of growing roots, stems and other organs of the plant; it is developed in varying strength in different organs; it sets up movement of the organ in response to stimulation; the direction of movement will depend upon the specific kind of sensibility acquired by that organ; the direction of the movement will always bear some definite relation to the vertical without regard to the position of the plant.

But, what other senses have plants? Next to a proper position, most plants need a suitable exposure to light. I shall not attempt to show the numerous and wonderful ways in which plants respond to light. Everyone knows how plants lighted from one side, as when placed before a window, bend toward the light. This is a true sensitiveness, for it results in bringing about definite movement. It is not, however, at all like seeing, for it will be noticed that it is not the amount of light, but the direction of light to which the organs respond. The stems place themselves parallel to the direction of the incident rays—that is, point toward the window, while the leaves place themselves at right angles to the direction of the light—that is, with their upper surfaces to the window. Leaves and stems, therefore, show a sensitiveness characteristic of each. Some stems, however, like those of the Virginia creeper, turn away from the light, enabling them to cling to dark walls. Roots, which are generally buried in the soil, rarely exhibit sensitiveness to light, and when they do, it is usually to turn from it. If light comes to the organ from two directions, it will bend toward the source of the stronger light, and differences which will affect the plant are far more minute than can be detected by the eye.

As in the case of roots, certain stems place themselves, not parallel with the direction of the light, but at some particular angle to it, in accordance

with some inherent necessity. Not as many parts of the plant, as a rule, are sensitive to light as to gravitation, but the degree of development of the sense is often greater.

Some plants also show a sensitiveness to moisture, especially in their roots, causing them to bend toward or away from the moist surface. Certain molds are remarkably sensitive in this way. Errara presented a paper before the British Association, last year, in which he gave the results of his experiments with *Phycomyces nitens*, a tall-growing mold. It proved to be so sensitive that the experimenter was enabled to detect the hygroscopic character of certain substances not before known to be in the least degree hygroscopic. Thus it bent toward alum, and careful physical tests showed that alum was truly hygroscopic to a minute degree, although the property had never before been ascribed to it.

Certain plants are also sensitive to heat. Here, again, it is the direction of the radiant energy, rather than the amount, to which they respond. In my own laboratory, experiments have shown that young plants of corn will bend toward the source of heat, which in this case was a lamp placed behind a screen of blackened tin, while beans bent away from it.

But probably the most varied and wonderful of all the plant senses is the sensitiveness to contact. In the animal the somewhat similar sense of touch is more diffused over the body, and takes on more variety than any of the other senses, and in plants it has even greater diversity than in animals. In the tendrils of certain plants, notably in the passion vine (*Passiflora carulea*) "this sensitiveness is often exquisitely fine, indeed, it seems more delicate than the tactile sense of animals." Unlike the other plant senses, it has risen above the necessity of being confined to young, growing parts, and sometimes resides in special organs, as in the cushions on the leaves of the sensitive plant, by which they are able to suddenly shut up tightly when touched, or in the prehensile-like tentacles of the leaves of sundew, which shut over and catch a live insect and secure it for digestion by the plant.

Plants are thus seen to react sensitively to gravity, light, moisture, heat and contact. Each is a special kind of sensitiveness, having its own method of reaction. Two or more kinds of sensitiveness may reside in the same organ, when its position will be a resultant of the several forces. There are, consequently, no exclusive organs of sense, although there is more or less localization in certain parts; and there are no nerves, although the motor impulse may be transmitted some distance, even as

far as twenty inches or more in very vigorous sensitive plants, that is, in *Mimosa*.

To complete the comparison I should say there are no muscles in plants, although they execute movements of very considerable amplitude. The real mechanism by which the movements are accomplished, is not well understood. There is agreement, however, in assuming it to be due to the movement of water. Herbs, and the soft parts of all plants are kept distended and firm by internal water pressure, just as a rubber bag would be filled and made tense if tied to an open faucet of the city water works. Each cell acts like a separate distended bag. By stimulation the water is made to flow from the various cells in one side of the organ into the empty spaces surrounding the same and contiguous cells; the pressure is released on one side and the organ bends over in that direction. But this process is much complicated by growth, and other conditions too recondite to be explained here.

There are some peculiarities of plant senses which need special emphasis. All the senses, except that of contact, have for their end the adjustment of the plant as a whole, and of each of its organs, in a suitable position for best development. The contact sense has been more variedly developed, aiding the plant to climb, to catch insects for food, and if we are to accept Darwin's suggestion, to enable the sensitive plant in particular to escape the injury of hail storms. All the movements are very slow, except a few like the insect-catching and hail-avoiding movements, and their wonderful diversity and extent are only realized by instituting carefully devised experiments, and the use of delicate instruments.

It is also to be noted that the same organ always responds to the same stimulus with the same corresponding movement. If, for instance, the light strikes a shoot from the east, it bends toward the east, if possessed of positive direct irritability. There is no opportunity for choice. The plant secures a diversity of movement by having each set of organs endowed with their own specific form of irritability. As there is no choice in the character of the response, so there can be no volition, and consequently no mental activity, no psychic life, even of ever so humble and rudimentary nature.

This brings us back to our starting point. When we trace the development of irritability as a universal property of protoplasm into its various phases of sensibility, and mental activity, the first and fundamental division of organic life is into fixed and motile organisms, without regard to

its animal and vegetal nature. To the motile forms belongs a psychic or mental character, whether they be animals or plants. A most interesting exposition of the psychic development attained by motile plants, like the *pandorina*, *volvox*, and other small (essentially microscopic) forms, comparing them with animals of a similar degree of complexity, is given in Binet's work on the psychic life of micro-organisms, a work without sensational features, and with many suggestive and interesting statements. But fixed plants have no psychic life; their sensibility does not rise above that of specific irritability, although often attaining a marvelous development. Aristotle's notion, which is still too prevalent, of an ascending complexity in vital phenomena from plants to man, should be wholly abandoned. The only way of viewing nature, to secure proper interpretation, is that of two parallel lines of development, one through motile forms, and the other through fixed forms. Each line of development has worked out peculiarities of its own—in fact, there is little agreement. If the special senses of man and the higher animals show wonderful adaptations, the special senses of plants, although very dissimilar, will, when well known, appear quite as remarkable.

The observation of Sachs, the venerable professor at Würzburg, and one of the most far-seeing of physiological botanists, is particularly pertinent in this connection. "We have no necessity," he says, "to refer to the physiology of nerves in order to obtain greater clearness as to the phenomena of irritability in plants; it will, perhaps, on the contrary, eventually result that we shall obtain from the process of irritability in plants data for the explanation of the physiology of nerves, and this, although it is as yet a distant hope, gives a special attraction to the study of the irritable phenomena of plants." The attitude of botany as a science in its historical development toward plants as objects of study, has been most happily characterized by Professor Patrick Geddes, of the University College, Dundee, whose words I shall use in my closing remarks: "To the dawning intelligence of the race, the forest is vaguely astir with a life which man does not clearly separate from his own—a mystery of growth which has left its mark deep in the history of all religions. A later and more self-conscious mind molds this omnipresent life into anthropomorphic shapes; so a Dryad hides in every tree, while Pan roams through the glade. These anthropomorphic shapes are next formalized away from the living realities they symbolize; they become mere shadowy gods, then fairies and fables. The tree (or what remains of it) is now something

economically useful ; it has also a popular and a systematic name ; but to utilitarian and Linnæan alike, the form and substance seems the main thing, not the life. 'Great Pan is dead,' the botanist is as prosaic and unseeing as the woodcutter, in fact, essentially is one ; at best with finer tools, and like him does his best work away from the wild wood altogether. But as the ages of fetishism, of Hellenic anthropomorphism passed away, so now the formal and utilitarian and analytic spirit is passing also in its turn. Science is entering a new and brighter Hellas ; the Dryad, living and breathing, moving and sensitive is again within her tree ; nay, better, the plant is herself the living Dryad, her beauty radiant in the sun."

PAPERS READ.

GEOLOGY.

ON THE INDURATION OF CERTAIN TERTIARY ROCKS IN NORTHEASTERN ARKANSAS. By R. ELLSWORTH CALL

In northeastern Arkansas, west of the St. Francis river, stretching from the Missouri line to the Mississippi river at Helena, is Crowley's Ridge, the only pronounced topographic feature in the region. The width of this particular ridge varies from six or seven miles to a half mile, the northern portion being the widest. The general geological features of Crowley's Ridge have been elsewhere given* and need not be rehearsed at this time. It will be sufficient to say that the ridge is the remains of a plateau to the westward of which once flowed the Mississippi river which cut out the great valley now occupied by the White and Black rivers and other streams of the region. Later its channel was changed to the eastward by the penetration of the previous barrier near Cape Girardeau, in Missouri ; it still occupies a portion of that ancient valley across which it has several times shifted its course. It has resulted from these great changes that the eastern valley has been dug deeper and wider than was the ancient channel on the west. Crowley's Ridge, therefore, stands as a residual product of erosion.

* *Vide* Geological Survey of Arkansas, report for 1889, Vol. II, "The Geology of Crowley's Ridge," by R. Ellsworth Call.

The investigation of the ridge, which was undertaken under the direction of the Arkansas geological survey, revealed its general geological structure to be about as follows: The top of the ridge is, in portions of its extent, capped with pleistocene deposits of relatively both early and late epochs. The newest deposit of value is the loess which caps or lines the highest portions of the ridge; this material shows a bi-partite character which is believed to be connected with at least two glacial epochs the facts concerning which have been collated and discussed by Messrs. Chamberlain and Salisbury in several papers in the geological journals. Below this material, where it crowns the ridge, is a heavy deposit of a cherty gravel, much ferruginized, water-worn, not well assorted, and of varying thickness. This is elsewhere shown to be of tertiary age. Below this member is a great thickness of tertiary sands, usually non-indurated and soft, yielding readily to erosive action. The lowest member disclosed to the observer is made up of alternating pure and sandy clays, with much lignite in masses or disposed in great beds often many feet in thickness. Towards the base of the exposed clays many localities have yielded large numbers of fossil leaves which determine the age of the clays as early eocene. Added to their evidence is that furnished by the rather rare localities where fossil shells have been found. These are all marine and are unequivocally eocene. At numerous localities in the northern half of the ridge the gravel member alone forms the highest points of the hills the loess, if it ever existed there, having been entirely eroded away. The gravels often have small masses of a very compact and fine grained quartzite and much rarer large masses often weighing several hundred pounds. These increase in frequency along the west side of the ridge until near the Missouri line, some twenty-five miles south of it, where they no longer appear. They are usually quite white in color but in the gravels the smaller ones seem to have acquired the characteristic ferruginization of the gravels of the orange sand.

It happened that one of the problems connected with these nodular or pebbly quartzites related to their origin. They presented nothing in common with such quartzites as are familiar to all students of the northern drift and were to be in no way connected therewith. It was noticed that they became more and more abundant as progress was made towards the northern portions of the ridge, but this fact only added another phase to the riddle to be solved. Dr. D. D. Owen, whose geological work needs no introduction or word of commendation to an Indiana scientist, had years

before our visit made some hasty examinations of this portion of Crowley's Ridge. On pages 28-29 of his report on his work in this section he called attention to* a low "range of quartzose sandstone" which had "all the lithological characters of the Potsdam * * *, as it occurs on the Minnesota and Wisconsin rivers in the northwest." Two localities had been noticed by him both of which were in Craighead county. The reference of these rocks to the Potsdam or to any part of the paleozoic made the locality one of great interest, occurring, as it does, in the heart of a region of pleistocene soils underlain by rocks known to be of tertiary age. There was a peculiar satisfaction when Mr. William Lane piloted me to the very spot where, forty years before, he had piloted Dr. Owens and placed me on the pinnacle of the very rock from which that eminent geologist had looked over the heavily forested valley of the Cache. It is not surprising that these rocks were with some hesitation referred by Owen to the Potsdam. They present every characteristic of the Potsdam of northern New York except that they are entirely devoid of fossils, or at least this locality yielded none. His reference was plainly made from lithologic characters and though wrongly made was excusable for his time. This particular locality is at the foot of a high spur of the ridge forty feet or more above the Cache bottoms. The hills are high and are crowned with heavy beds of gravel which, in turn, are overlain by a thin sandy and gravelly soil supporting a strong growth of the common short leaved pine (*Pinus mitis*) and much scrub oak. At this point the quartzose bed is a huge mass of very hard rock, ringing like clinkstone when struck with the hammer, having its sand grains and the few accompanying pebbles well waterworn and exhibiting the characteristic structural features of sandstones deposited in swiftly running waters or tide swept shallows. The dip that appeared so patent to Owen developed into simply planes made by false bedding. A few hundred feet north of the roadway across which this mass of rock extends, in a deep ravine in which the rock is exposed to excellent advantage, the sandstone outcrops as a series of ledges from near the level of the bottoms to a point two-thirds of the way up the hill, thus showing a thickness of fully ninety feet. The several strata are from five inches to five or more feet in thickness and are nearly or quite horizontal. The total exposure of the rocks in this locality is about half a mile in length. At this point the underlying strata could not be seen

*First annual report of a geological reconnoissance of the northern counties of Arkansas. Pp. 28-29.

but a section beneath non-indurated sandstones of the same age exposed on a small stream about three miles south of this locality discloses the horizontally stratified clays of the tertiary. From Lane's to the southernmost part of the county where the outcrops cease two or three less important exposures occur.

Several other outcrops are to be found in Crowley's Ridge but with one or two exceptions, they are all on the west face of the ridge. The most important are all in Greene county and all present practically the same characters and vertical distribution. The northernmost exposure is in R. 19 N., 6 E., section 19, where they appear for the last time as indurated sandstone. They here outcrop in and extend across the road and disappear to the west in a low hill which rises a few feet above the Cache bottoms. To the east the outcrop extends for several hundred feet into the ridge, as traced in a deep ravine, where it is surmounted by a two foot layer of exceedingly hard, fine-grained, flint-like sandstone. The highest point above the valley which is crowned by these rocks has a barometric elevation of about one hundred and fifty feet above the lowermost rocks and these are in turn some forty feet above the valley. In but one locality on the west side did fossil plants or fossils of any sort occur in this sandstone. This was in 17 N., 4 E., in section 10, where after a long and difficult search a small fragment of a plant was found deeply imbedded in the very hardest rock which here caps the hills. It possessed very little structure but it was quite sufficient to determine the rocks to be of tertiary age. However, the form was not sufficiently well preserved to tell us exactly to what part of the tertiary the rock belonged but the evidence which was wanting here was later supplied a little further on. We now had the necessary clew and now the work of unravelling the mystery of the ridge was play! To make a long story very short these sandstones of supposed paleozoic age, standing isolated in the midst of tertiary rocks through which they boldly protruded their waterworn and time begrimed tops were found to be themselves tertiary and to share in the common history of the region.

A secondary problem now concerned the process or cause of induration; a process which had been so complete and left so little traces that a score or more geologists had been puzzled into determining these rocks as of paleozoic age. So to this task were the succeeding investigations directed.

All of the outcrops of quartzitic sandstone occur in about the same vertical position in the hills. They are to be found as spurs, extending in

various directions from the main axis of the ridge, or at the heads of ravines. They may extend from the bottom of the hills to near their top, or they may form a layer of only a few feet in thickness at the very top. In every case the outcrops are found to be surmounted with a series of very hard layers which are usually from one to three feet in thickness. In several places they pass into the soft sands beneath and these in turn give way to the ordinary tertiary clays still further down. In nearly every case the rocks weather greenish and are irregularly stratified. In one locality, near Hardy's Mill, in Greene county, occurred numerous fossil leaves among which there have been determined *Magnolia* and *Kalmia* leaves; the entire absence of beech, chestnut and hornbeam leaves among those found indicate the base of the tertiary rather than any portion of the tertiary above the eocene. This is the position in the geological column assigned these forms by Professor L. W. Ward, who studied the materials collected by the writer.

The result of the studies made on these irregular deposits, occurring with such extreme irregularity in the ridge and of such peculiar hardness, stated in brief, was that they were metamorphosed sandstones. The compact character of the quartzites, their glassy surface on fracture, which is remarkably conchoidal, might lead one to imagine dynamical disturbances of marked nature. But there are no attendant facts such as continuity or great extent of surface. They are exhibited in localities some distance removed from each other and with no connecting deposits that show any metamorphic characters. But that they have become indurated on exposure, here and there, and constitute immense quartzite blocks, often acres in extent, was evident. At a locality known as Lovelady's, on Beech creek, in Greene county, there are several exposures that are quite hard on the surface but are softer within, finally yielding to moderate pressure to say nothing of blows. From this point to that of greatest induration is but a few hundred yards; it was hence concluded that the metamorphic processes were still in vogue and these most certainly were not dynamical in character. In Brazil, Dr. J. C. Branner has observed similar facts of metamorphosis,* and these corroborate the view here suggested of metamorphism through weathering processes. Where longer weathering has obtained the masses are often rounded as if water worn, but in the great number of exposures this feature is scarcely apparent.

*Transactions Am. Phil. Soc., 1889, XVI., pp. 419-420.

Summing up the facts, then, in few words these rocks are of limited occurrence, covering a few hundred acres all told; they are found at rather low elevations in the hills though they sometimes occur as far as the very tops of the highest points in the ridge country; they have yielded fossils of lower or eocene tertiary age; they have probably resulted from weathering processes; are metamorphic in character; and have no history of dynamic origin or of present or past dynamic change. Their former reference to the paleozoic is no longer tenable and they stand as a unique instance of the induration of soft sandstones in the southwest.

The sketch map accompanying gives that portion of Crowley's Ridge in which indurated sandstones have been found. It will serve to indicate the relations of the ridge to the low-lying country surrounding as well as helping to make clear the geographic distribution of the quartzites.

THE WHITE CLAYS OF INDIANA. By AMOS W. BUTLER. Published in the Trans. of the Ind. Horticultural Soc. for 1893.

BIOLOGY.

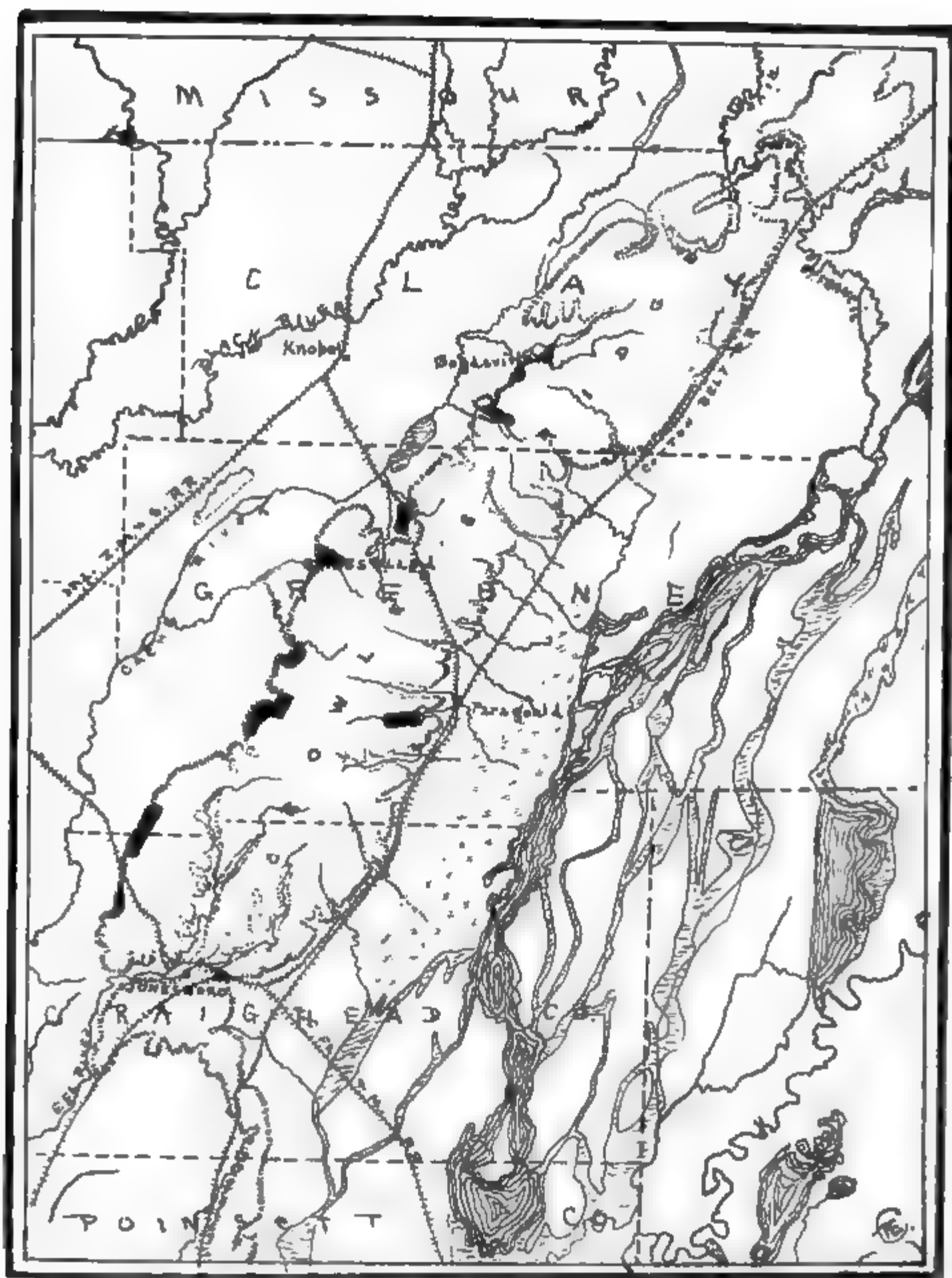
ON THE HABITS OF TURTLES. By A. W. BUTLER.

[ABSTRACT.]

In the White Water valley the soft-shelled turtles are never found active in winter. They seem to seek the deepest water and then bury beneath the surface of the mud or sand. They disappear earlier in the fall and reappear later in the spring than the hard shelled forms. They rarely appear before April 15th, and sometimes not until about May 1st. In the canal none have ever been found in winter. Possibly they seek the deeper water. The hard-shelled turtles winter in the more shallow water, and seem to prefer a mud bank where a musk rat hole has caved in. There they may be found by prodding with an iron rod.

ON THE OCCURRENCE OF KIRTLAND'S WARBLER (*Dendroica kirtlandi* Baird) IN INDIANA. By A. B. ULREY.

Owing to the rare occurrence of Kirtland's Warbler in North America and the fact that its life-history is almost entirely unknown, considerable



NORTH HALF CROWLEY'S RIDGE

■ Metamorphosed Sandstones (Eocene).



interest attaches to the presence of the bird in Indiana. At the time of publication of their "History of North American Birds" in 1874, Baird, Brewer and Ridgway gave the locality as the eastern provinces of the United States and the Bahamas. "It must be considered" they state "as one of the rarest of American birds. Kirtland's Warbler is so far known by only a few rare specimens as a bird of North America and its biography is utterly unknown." Three specimens are then recorded as taken, two from Cleveland, O., and one at sea between the islands of Abasco and Cuba.

Dr. Elliott Coues in his "Key to the Birds of North America" published in '84 gives the locality as "Eastern United States." Of its occurrence he states that it is "the rarest of the Warblers; only about a dozen specimens known thus far."

Its habitat is given as "Cuba" by Ridgway in his "Manual of the Birds of North America" published in 1887.

Because of its occurrence in the adjoining states, Ohio and Michigan, Mr. A. W. Butler in his "Catalogue of the Birds of Indiana" places Kirtland's Warbler in his hypothetical list.

There is no record, so far as I can learn, of its occurrence in Indiana other than the present one. The bird is known to me only by a single specimen that was taken May 4th, '93 and handed to me the following summer for identification. It proved to be the rare *D. kirtlandi*. The skin is now in the collection of Mr. W. O. Wallace, Wabash, Ind., who took the bird near his home. Concerning its habits, he says: "I took it in a thicket. It was by itself, there being no other birds in the thicket. It seemed to be an active fly catcher, not having the motions of the other *Dendroica*, being less active. It would dart off after an insect and then return to the same perch."

THE GEOGRAPHIC AND HYPSONETRIC DISTRIBUTION OF NORTH AMERICAN VIVIPARIDÆ. By R. ELLSWORTH CALL.

[ABSTRACT.]

There are four genera of this family in American waters and these exhibit a varying number of species. The paper recognizes *Campeloma*, *Vivipara*, *Lioplax* and *Tulotoma*. There is given the general range of each

form in the various drainage systems; but little attention is paid to matters of synonymy, for these have been elsewhere treated. The main facts in geographic distribution are presented in compact form and then further illustrated by a map of distribution in which the extreme limits of range are shown.

The hypsometric facts are separately presented; the altitudes of various of the forms are given on the authority of the "Dictionary of Elevations" published by the U. S. G. S. The several ranges are compared and the facts are then generalized for the species of each group. Attention is called to the extremely limited range, both geographically and hypsometrically, of the genus *Tulotoma*.

This paper may be found in full in the American Journal of Science for August, 1894.

ON SOME SOUTH AMERICAN CHARACINIDÆ. By A. B. ULREY.

[ABSTRACT.]

A study of the Characinidæ collected by Charles Frederic Hart in Brazil shows that he found 47 species, seven of which are new. Four of the new species belong to the genus *Tetragonopterus*, one to *Mylesinus* and two to *Aphyocara*. Descriptions of the new species will be published in the annals of the New York Academy of Science, together with notes on the specimens examined and analyses of the species of *Cheirodon*, *Aphyocara*, and *Tetragonopterus*.

THE EFFECT OF ENVIRONMENT ON THE MASS OF LOCAL SPECIES. By CARL H. EIGENMANN.

Nearly every family of fishes represented on the Pacific slope of North America has one or more of its representatives modified in a certain direction as compared with its Atlantic slope relatives. The modification consists in the increase of the number of rays of one or more of the fins or in the modification of some of the rays into spines.

In most families the differences between the Atlantic and the Pacific slope representatives are just perceptible, and, were it not for the consensus of differences in all groups would stand for nothing.

The most marked difference is found in those fishes which have been separated from their Atlantic slope relatives long enough to become generically distinct. In several genera, *Meda*, *Lepidomeda*, *Richardsonius* (sub-gen.) *Columbia* the modifications of the fins mark the genus.

The more striking modifications are the following :

In the sub-genus *Richardsonius*, confined to the Columbia and to the Fraser systems, the number of anal rays varies from 12 to 25, which is an increase of from 2 to 15 rays over the species of *Leuciscus*, some of which have also (more recently) entered the head waters of the Columbia but the great bulk of whose species inhabit the Atlantic slope.

The genus of *Oncorhynchus* confined to the Pacific slope has a similar increase of anal rays over *Salmo* and *Salvelinus* which are genera of wider distribution, some of the species entering streams of the Pacific slope.

The above are examples of the addition to the number of rays in the fins.

The modification of some rays into strong spines is seen in the Minnows, *Meda* and *Lepidomeda*. Among the many Atlantic slope Minnows none have spines in their fins while *Meda* and *Lepidomeda*, confined to the Rio Colorado, have two spines to the dorsal fin, the posterior received into a longitudinal groove of the anterior.

The increase of spines is very strikingly illustrated in the Sun Fishes (Centrarchidæ) in which the single Pacific slope species, *Archoplites interruptus* (Girard), has one more dorsal spine than any of the numerous Atlantic slope relatives.

We must either assume that there has been in all the families a fortuitous variation in one direction which has enabled natural selection, which favored larger finned fishes to produce the present results, or we must admit that the environment has affected all species alike and the effect of this action has by heredity become gradually the established order of things. In other words we must either explain the conditions with the Neodarwinians through natural selection or we must with the Neolamarckians believe in the acquisition of larger fins through greater use of these organs and the subsequent transmission of the modification to the offspring.

These modifications being in one direction are unquestionably due to one definite environmental cause. What that cause is I am unable to say. A comparatively short, swift, water course suggests itself most naturally but the species inhabiting the short, swift, streams of the western

slope of South America show no such variation from their Atlantic slope relatives. They would do so were the shortness and swiftness of the river the cause.

The most striking example is offered by the *Percopsidæ* with a single species on the Atlantic slope and another on the Pacific slope. *Percopsis* on the Atlantic slope has feeble unsegmented rays in front of the dorsal and in front of the anal which in *Columbia* on the Pacific slope are transformed into strong spines.

Similar structural peculiarities are to be observed in other regions. Mr. A. J. Woolman informs me that all the minnows of Mexico have the teeth in one row and four teeth in each row. Such uniformity is not found elsewhere in America. This peculiarity being found in *all* the species may be explained by the application of natural selection. The peculiarity of the food is probably such as to bar the road to Mexico to all but species with the teeth 4 to 4 or to kill off any that may have entered this region, the minnows of Mexico having all entered from the north.

Lake Titicaca in the high Andes of South America is inhabited by a peculiar genus of Cyprinodontidæ (*Orestias*). The numerous species all lack ventral fins. Perhaps no one would be willing to insist that each of these species formerly possessed ventral fins and lost them through environmental influences independently. The only plausible explanation seems to be that they have diverged from a parent stock which had lost its ventrals before it split into a number of species. But five other genera of freshwater fishes are known to me to lack ventral fins. They are:

Apua, a Minnow—Tennaserim.

Tellia, a Cyprinodont—Alpine pools of the Atlas.

Astroblepus—Rio de Palace near Popayan (in the Andes.)

Eremophilus—Bogota (in the Andes.)

Channa—Ceylon.

A glance at this list will show that four of these six inhabit high mountain waters. (The character of the water of the Ceylon species is not stated.)

Now, while not all mountain fishes lack ventral fins, the fact that two-thirds of the fishes lacking ventrals inhabit mountain homes, half of them living in the waters of the Andes seems to indicate that here, as in the Pacific slope fishes, we have a case of convergence—that we have to deal with a character several times produced in remote types by the direct influence of the environment. Since the genera lacking ventrals

inhabit Alpine waters in remote parts of the globe the environment which has caused this convergence is limited to the conditions obtaining in Alpine waters. A closer definition of the acting cause in the reduction of the ventrals I am unable to give.

In the last two instances I have but given facts which have forced themselves on my notice. The conditions obtaining on the Pacific slope were determined after a careful comparison of all Pacific and Atlantic slope species and the details of this comparison will appear in the publications of the U. S. Fish Commission.

ON THE FISHES OF WABASH COUNTY. By A. B. ULREY.

The present paper is presented as a contribution to the biological survey of Indiana. It is apparent that before any complete survey of the fauna and flora of the state can be made there must be a large number of local lists of animals and plants representing the different regions of the state. While the county forms in no sense a faunal area, there are numerous obvious reasons for making county lists. It is perhaps not essential that these local lists should cover faunal areas. When sufficient data are at hand the matter can then be placed in systematic order.

Wabash county is situated in the northern third of the state a little east of a line passing through the centre north and south. The Wabash river, flowing a little south of west, passes through the county near its centre. Eel river flows across the northwestern part and the Mississinewa crosses the southwest corner, both of which finally reach the Wabash.

The list here presented contains most of the fishes that occur in considerable abundance in the county and some that are found only occasionally. It is desired that it may be completed by some one in this region and notes made on the spawning, life-habits and environment, presenting a complete record of the ichthyology of the county.

The collections here represented are a part of more extended collections in other groups of animals and several groups of plants made by different members of the Wabash County Science Club.* A series of the fishes of the following list has been placed in the museum of Indiana University, one in the museum of North Manchester College and another in the pri-

* This material is in preparation for the biological survey of the state.

vate collection of Mr. William O. Wallace, Wabash, Ind. All of the specimens were taken in the northern half of the county in the following streams.

CATOSTOMIDÆ.

1. *Ictiobus relifer* (Rafinesque). Kentner's creek.
2. *Catostomus teres* (Mitchill). Hellem's creek; Paw Paw creek.
3. *Catostomus nigricans* Le Sueur. Eel river.
4. *Moxostoma anisurum* (Rafinesque). Kentner's creek.
5. *Moxostoma macrolepidotum* (Le Sueur). Paw Paw creek.

CYPRINIDÆ.

6. *Campostoma anomalum* (Rafinesque). Kentner's creek; Paw Paw creek.
7. *Pimephales notatus* (Rafinesque). Kentner's creek; Paw Paw creek.
8. *Notropis deliciosus* (Girard). Kentner's creek.
9. *Notropis whipplei* (Girard). Eel river; Kentner's creek.
10. *Notropis megalops* (Rafinesque). Hellem's creek; Kentner's creek; Paw Paw creek; Eel river.
11. *Notropis ardens* (Cope). Paw Paw creek.
12. *Notropis umbratilis* (Girard). Kentner's creek.
13. *Notropis atherinoides* (Rafinesque). Eel river.
14. *Ericymba buccata* (Cope). Kentner's creek.
15. *Rhinichthys atronasus* (Mitchill). Kentner's creek.
16. *Hybopsis amblops* (Rafinesque). Eel river; Kentner's creek.
17. *Hybopsis kentuckiensis* (Rafinesque). Eel river; Paw Paw creek; Kentner's creek.
18. *Semotilus atromaculatus* (Mitchill). Hellem's creek; Kentner's creek.
19. *Notemigonus chrysoleucus* (Mitchill). Hellem's creek.

ESOCIDÆ.

20. *Lucius* (Esox) *lucius* Linnæus. Paw Paw creek.

GASTEROSTEIDÆ.

21. *Eucalia inconstans* (Kirtland). Kentner's creek.

CENTRARCHIDÆ.

22. *Ambloplites rupestris* (Rafinesque). Eel river; Paw Paw creek.
23. *Chanobryttus gulosus* (Cuv. and Val). Loc.?
24. *Lepomis cyanellus* (Rafinesque). Paw Paw creek; Hellem's creek.
25. *Lepomis pallidus* (Mitchill.) Loc.?

26. *Lepomis megalotus* (Rafinesque). Paw Paw creek; Kentner's creek.
27. *Lepomis gibbosus* (Linnæus). Paw Paw creek.
28. *Micropterus dolomieu* (Lacépède). Eel river; Paw Paw creek.

PERCIDÆ.

29. *Etheostoma pellucidum* Baird. Eel river.
30. *Etheostoma nigrum* Rafinesque. Paw Paw creek; Eel river; Kentner's creek.
31. *Etheostoma blennioides* Rafinesque. Eel river; Paw Paw creek.
32. *Etheostoma aspro* (Cope and Jordan). Paw Paw creek.
33. *Etheostoma flabellare* Rafinesque. Eel river.
34. *Etheostoma coeruleum* Storer. Eel river; Paw Paw creek; Kentner's creek.

COTTIDÆ.

35. *Cottus richardsoni* Agassiz. Kentner's creek.

AN ALPHABETICAL AND SYNONYMICAL CATALOGUE OF THE ACRIDIDÆ OF THE
UNITED STATES. By W. S. BLATCHLEY.

VARIATIONS IN THE COLOR-PATTERN OF *ETHEOSTOMA CAPRODES*. By W. J.
MOENKHAUS.

[ABSTRACT.]

In examining a representative number of *Etheostoma caprodes* from localities covering practically all the territory of its distribution. It was found that there existed a great variation in the color-pattern and that this variation showed a definite line of development.

The simplest coloration consisted of alternate long and short vertical bars developed on the body from the head to the base of the caudal. This simplest coloration was the prevailing pattern of the specimens taken from the streams of Indiana. Four specimens from the Alabama river differed only in that the bars were very much broader and more intensely colored.

In the specimens taken from certain tributaries of the Cumberland and

Tennessee rivers there was developed between each of the above long and short bars a still shorter and narrower bar, so that the coloration here consisted of whole, half and quarter bars. The Arkansas river also afforded exact representatives of this pattern.

Between the two patterns described every possible gradation was found. The quarter bars made their first appearance between the fifth and sixth whole bars. The whole bars toward the posterior end of the body increased in width and intensity of color near their ventral limit so as to give rise to an incomplete longitudinal series of lateral spots. These spots were more evident in the pattern consisting of whole, half and quarter bars.

Specimens from Texas showed the bars less regularly developed with a corresponding increase in the extent and distinctness of the series of lateral spots.

A great number of specimens taken from other tributaries of the Cumberland and Tennessee rivers all showed the longitudinal series of nine, almost confluent black lateral spots very highly developed, while the bars had become so modified as to form quite a close network over the dorsal half of the body. The young of this pattern had the spots less strongly developed, and the original bars could be easily traced.

It seems, thus, that the variations in the color patterns in *E. caprodes* are by no means promiscuous, but that they show a serial passage from one form, that consisting of alternate whole and half bars, through the form consisting of whole, half and quarter bars, and having the incomplete longitudinal series of lateral spots more highly developed to the reticulated form having a very prominent longitudinal series of dark lateral spots. I was unable to discover any relation between these variations and the latitude in which they occurred.

SOME QUERIES RELATIVE TO A SUPPOSED VARIETY OF SOLANUM DULCAMARA. By
R. W. MCBRIDE.

The books describe the flower of the common Bitter Sweet, *Solanum Dulcamara*, as being purple in color. This, as is well known, is the usual color of the flower of this plant. Some six or eight years ago, however, I found in DeKalb county a specimen, which, while it in all other respects

resembled the common *Solanum Dulcamara*, had pure white flowers instead of purple. I sent a specimen of the plant with flowers to Prof. J. M. Coulter as a variety which I had not previously seen described, and asked for information. He informed me in reply that it was merely an albino sport. Silenced, but not quite satisfied, I continued my observations and learned that from the seeds of this plant were produced plants bearing white flowers only. I also found several other specimens in DeKalb and Steuben counties. In 1890, I changed my home to Elkhart, and there along the banks of the St. Joseph river, I found *S. Dulcamara* growing commonly, and also discovered that at least thirty per cent. of the plants bore pure white flowers. I am not a botanist, but a mere layman with the habit of occasionally using my eyes and thinking at the same time, and now appeal to this learned body for information. If I am not mistaken in my facts, and if in several counties of the state a large per centage of the plants of *S. Dulcamara* are white instead of the commonly purple color, should not the white specimen be denominated a variety? also is not the white variety a new and hitherto undescribed variety of *S. Dulcamara*? What does it take to constitute a variety of a species? How may we be assured that we have discovered a distinct variety and not a mere sport?

WORK OF THE BOTANICAL DIVISION OF THE NATURAL HISTORY SURVEY OF MINNESOTA. By D. T. McDUGAL.

NOTES ON AN EMBEDDING MATERIAL. By JOHN S. WRIGHT.

[ABSTRACT.]

A report was made of experiments upon a commercial "glycerine jelly," for embedding purposes. The jelly, a translucent glassy material, remains solid at temperatures below about 97° C. It is composed of glycerine, Na₂CO₃, and stearic acid, united at a temperature of 25° C. By adding alcohol in varying quantities four solutions were made which were used in infiltration of tissues. The experiments were not sufficiently extensive to establish the preparation as a valuable embedding material. All tissues used were vegetable.

NOTES ON SECTIONING WOODY TISSUES. By JOHN S. WRIGHT.

[ABSTRACT.]

The preparation of hard, woody tissues for sectioning is accomplished by heating the pieces to be sectioned a few minutes in a test tube containing a 75 per cent. or 50° glycerine solution. The woods may thus be quickly brought into condition for sectioning. In some instances the glycerine and heat distort the tissues, while in other cases, if carefully applied, they may restore cells, which have shrunk, to nearly their original outline. By this method, however, all starch grains of the cells are destroyed, and when it is desired to study cell contents fresh material must be secured.

CONCERNING THE EFFECT OF GLYCERINE ON PLANTS. By JOHN S. WRIGHT.

[ABSTRACT.]

Various potted plants were experimented with, particularly geraniums. Glycerine was administered to them in the water. 10, 20, 25 per cent. solutions were used. In some cases wilting was soon effected by the application of water containing glycerine. Some cases showed a temporary revival from the first noticed effects, again in other cases the plants died. Chemical tests were made of leaves of treated plants and of untreated ones (those of control experiments) and in nearly all instances treated plants were discovered to have contained glycerine in their tissues.

CONTRIBUTIONS TO THE HISTOLOGY OF THE PONTEDERIACEÆ. By E. W. OLIVE.

[ABSTRACT.]

Pontederia crassipes, a cultivated form, is taken as a representative of the order and its histological structure compared with the other species. It, however, is not typical, because of its higher differentiation. The diaphragm, of stellate tissue of these aquatic monocots furnish very interesting studies. These probably serve other more important functions than that of mere mechanical support. The active nuclei indicate a close connection with the vital processes of the plant.

The diaphragms in *Pontederia cordata* and *P. crassipes* are pierced by long spear-like crystals of calcium oxalate. Each of the latter are enclosed in a thick-walled sac. Also a secretion of a fatty-oil nature was abundant in all the partitions except those of *Pontederia crassipes*. Concentrated sulphuric acid placed on a section showed a beautiful example of continuity of protoplasm in the cells of the diaphragm.

GROWTH IN LENGTH AND THICKNESS OF THE PETIOLE OF RICHARDIA. By KATHERINE E. GOLDEN.

The subjects of growth and tension have such a close inter-relation that it is difficult to separate them in order to determine how much of the expansion taking place in a plant organ is due to growth and how much to tension. It is well to understand first what is meant by growth and what by tension.

Growth is a permanent change that takes place in an organ, usually accompanied by a change in bulk, and is dependent on constructive and destructive metabolism, an adequate supply of moisture, and a temperature between certain definite degrees. Tension, on the other hand, is a state of turgidity of the cells, *i. e.*, the cells are capable of absorbing water in such quantities that it causes considerable stretching of the cell walls; this will cause a pressure from within on the cell-wall, and where a cell forms part of a tissue, there will also be a pressure from without from the surrounding cells, thus setting up tensions in the various tissues. These tensions will, of course, cause the dimensions of an organ to change.

From work done by Kraus* it has been determined that organs diminish in bulk (estimated on diameters) from morning until afternoon, and increase until towards dawn. This depends upon the quantity of water which the organ contains, and again on gain by absorption and loss by transpiration.

To determine the laws governing some of these changes I made a set of experiments upon the petiole of Richardia. The petiole is made up of thin-walled parenchyma, having large, regular, inter-cellular canals and small, fibro-vascular bundles scattered through it, and enclosed by somewhat smaller parenchyma cells containing chlorophyll, alternating with groups of collenchyma cells, the whole being surrounded by the epidermis which has very thick outer walls. It can be seen from its structure that it would necessarily contain much water and air, and respond very readily to tensions.

To show how much water the plant may contain a set of experiments made by Ungert† who replaced the root pressure by a column of mercury in one case gave 26.5 grms. of water from 6 leaves in 11 days, and in another 36 grms. from 4 leaves in 10 days.

In my work I used self-recording auxanometers to make measurements,

*Kraus. Quoted in Vines Physiology of Plants, p. 405.

†Unger. Quoted in Physiology of Plants, Vines, p. 92.

the petiole being measured in diameter and length at the same time, so that there would be exactly the same conditions affecting the growth of the two dimensions. The plant was placed at a north window, and, while not receiving direct sunlight, had abundant light; the pot containing it was set in a saucer kept filled with water, thus providing a constant supply of moisture. The purpose was to keep the plant, as nearly as possible, under normal conditions while being measured.

The measurements of length show that a constant growth takes place, there being two periods in most cases during the 24 hours in which the growth was much greater than at other times, the maximum period of growth occurring from 12 o'clock midnight to 8:00 A. M., the lesser great period, where occurring, being in the evening. The growth in thickness was constant from day to day, as can be seen from the curves, but there were times during the 24 hours in which a contraction took place. The measurements, in every case, show that the diameter would increase gradually until a maximum point was reached, then diminish gradually, but not the entire amount that it had increased, thus proving that the increase in diameter was due to both growth and tension combined. The amount of growth is estimated for 24 hours by subtracting the sum of the increments of contraction from the total increase, thus leaving the sum of the increments of increase of the organ due to actual growth.

The measurements show that there were invariably two points of greater growth, the maximum occurring between 12 midnight and 9:00 A. M., this being the same time as the maximum period of growth in length occurs; the lesser great period occurring from 1:00 to 11:00 P. M.

These show a wider range in the occurrence of the greater and lesser points of growth than is found in woody stems, but is probably due to the nature of the structure of *Richardia*, which allows a ready response to variations in tension. This ready response was also shown by withholding water from the plant until the leaves become flaccid, then giving an abundant supply, when the leaves became turgid in about a half hour.

The curves show that the plant responds in expansion to an increase in temperature, though in two cases where the temperature went to 34° and 35° C. a contraction followed in one case, and a very slow growth in the other, seeming to indicate that a temperature of that extent was detrimental to the growth of the plant. This point would, of course, have to be worked out much more fully before anything positive could be deduced.

Theoretically growth in length and thickness should have their maxim-

um at the same point, but the measurements of *Richardia* show that while the maximum for each dimension occurred between midnight and the middle of the morning, it did not occur at the same time, sometimes there being a difference of 4 or 5 hours between the maximum for length and that for thickness. The curve for length shows that considerable growth took place, but as this is the result of the growth for the entire petiole, which consists of the sum of the increments of growth of its zones, while the growth in thickness is but that of a single zone.

The curves are constructed having the abscissæ represent periods of one hour each, the ordinates representing growth. One division of the ordinates is used as a unit for the curve of length; 3 being used for the curve of thickness that the changes may be seen more readily as they are so minute. The measurements were taken in millimeters, and as the instrument recording growth in length multiplied 8 times, if the number of spaces traversed by the curve be divided by 8, the quotient will be the number of millimeters of actual growth. The instrument for thickness multiplied by 40, and as three spaces were used as a unit, the number of spaces traversed would have to be divided by 120 to give the growth in millimeters.

THE EFFECT OF LIGHT ON THE GERMINATING SPORES OF MARINE ALGÆ. By
MELVIN A. BRANNON.

NOTES ON *SAPROLEGNIA FERAX*. By GEO. L. ROBERTS.

As to the sporangial development in the *Saprolegnieæ*, two important theories have been presented—that of Strasburger and the more recent one of Rothert.

The former holds that the partition wall of the sporangium, in *Saprolegnia ferax*, forms at a thickened place in the protoplasm. This changes into a cell-plate of varying thickness. The cell-plate is formed from a strong light-refracting substance, yellowish in color, which is apparently the same substance that is distributed in small granules in the protoplasm of the thread. From this cell-plate, after a time, arises the limiting

membrane. Later the partition wall becomes arched from the sporangium contents, and shortly, two membranes are formed, the one belonging to the sporangial portion of the thread, the other to the basal part.

The view of Rothert, confirmed by Berthold, Hartog, and others is, that at the arrest of the apical growth of the hypha, the protoplasm continues to flow in from the base, usually producing an ovoid enlargement. For a time the thick protoplasm of the sporangial part of the hypha passes gradually into the basal part, but the contrast soon becomes abrupt and well-defined. Then the granules disappear from the protoplasm, so as to form a somewhat elongated, transparent plasma ring, which increases at its inner circumference until it forms a transverse disk, that extends across the hypha from wall to wall. It is sharply marked on the basal side, but on the sporangial side passes gradually into the granular protoplasm. Within a very short time (about one-half minute), the transverse septum appears at the base of the disk. This septum is at first pale but soon becomes strongly defined.

Rothert thinks it probable, that the material for the formation of the septum is derived from the Pringsheim's cellulose corpuscles, consisting of a very soluble form of cellulose, that accumulate about the limiting area.

For the purpose of verifying one or the other of these theories, I made many serial cultures of *Saprolegnia ferax* on the bodies of dead flies, wasps, spiders, and crickets. By this means I was enabled to watch the development of the partition-wall. The time at which this was formed, in each instance observed, was in the morning. As to whether any especial significance attaches to this fact in this case, I can not say. In all cases the partition wall was formed as set forth by Rothert, and not as formerly suggested by Strasburger.

Another point first stated by Rothert was also confirmed; namely, that fragments of a healthy culture of *Saprolegnia* may be cut off and will continue to thrive in the hanging drop and are much more normal than the fly-leg cultures usually used. I found that fragments thus treated continued to grow and develop from day to day.

To make a study of the nuclei, I placed flies bearing *Saprolegnia ferax* in different stages of development, in a one per cent. solution of chromic acid for two hours; washed this material two days in distilled water; placed it in alum-cochineal twenty hours; and after again washing for a short time, brought it gradually into seventy per cent. alcohol, for preservation. By this process the nuclei are stained very nicely, and their

arrangement and development can be determined very satisfactorily.

In the vegetative portion of the hypha, the nuclei are of considerable size and lie in the inner part of the wall-lining of protoplasm. They are united by peculiar plasma threads, that run parallel or obliquely to the long axis of the hypha. The nuclei are ellipsoidal, elongated in the direction of the long axis of the hypha. One can determine the existence of a small nuclear body in each nucleus. In the hypha-ends the nuclei are nearer together. Here they are found somewhat closely connected in pairs, and lying entirely imbedded in the wall-lining of protoplasm. After the formation of the partition wall, they increase in numbers, by division, in the sporangial portion, and in the mature sporangium each zoospore contains a nucleus.

CONTRIBUTIONS TO THE LIFE-HISTORY OF NOTOTHYLAS. By D. M. MOTTIER.

[ABSTRACT.]

This paper embodies the results of a study of the development of the sporogonium and sex-organs of *Notothylas orbicularis* together with that of *Anthoceros*. These results may be summed up as follows:

The capsules of *Notothylas orbicularis* possess a columella varying in size with that of the capsule.

The columella is developed, as in *Anthoceros*, primarily in the young sporogonium with the archesporium and independent of it, and is not a secondary differentiation inside the spore chamber.

The archegonium of *Notothylas* resembles more closely that of the en-sporangiate ferns than does the archegonium of *Anthoceros*.

The antheridium arises from an hypodermal cell, thus differing in this respect from all other known *Bryophytes*.

THE ASH OF TREES. By MASON B. THOMAS.

The object for which this investigation was undertaken was to show by chemical analysis the amount of food a tree or shrub takes from the soil in its yearly growth. The method employed was to determine by a quantitative analysis of the ashes of trees and shrubs, the proportion of the mineral constituents of the soil that are found present in them. It seems

evident that such an investigation would be of importance to the cultivator of trees, and more particularly to the fruit grower, since by determining the drain upon his land he would have a knowledge of the needs and conditions of orchard soil, and also be furnished with some valuable information regarding the care of land on which trees are to be grown. There are but few fruit growers who know with any degree of certainty regarding the exhaustion of orchard soil, in consequence of which they apply fertilizers that may or may not be for the good of the soil, and an application of a surplus of fertilizers is not only a waste of money but is found to be actually injurious. It may often be that much money is wasted in the purchase of fertilizers rich in potash salts when the less expensive sodium salts would answer as well. An analysis of the soil on which an orchard is to be planted would at once show its condition, and knowing the proportion of mineral constituents taken from the soil in the yearly growth of trees, the fruit grower would be furnished with accurate information regarding the suitability of his land for orchard purposes, and would also know the exact constituents he could most profitably apply in his fertilizers. An analysis of the ash of two trees of the same variety, one of them attaining yearly a very vigorous growth, and the other, as it were, starving, would show, unless the stunted growth was due to a lack of proper drainage, the food that should be given to the exhausted tree for its support.

The work done by chemists upon the subject under consideration is comparatively little. Much has been done upon the amount of nitrogen and ammonia assimilated by trees, but little upon the amount of mineral constituents taken from the soil. More prominent among those who have worked upon the former subject are Justus von Liebig, Messrs. Veille and Blossingault. Some results upon the analysis of apple twigs have been published by Prof. G. E. Patrick, of the Iowa Exp. Station, but few results regarding their mineral constituents were given. Much has been done by Schroder, H. C. White of Georgia, and others upon the analysis of the mineral constituents of forest trees, but no results are given regarding fruit trees or shrubs.

An exhaustive investigation has been made of the amount of mineral constituents taken from the soil by tubers, cereals, etc., and valuable conclusions drawn. The best of these results can be found in the *Journal of the Royal Agricultural Society*, series 11, vols. 7, 8 and 13.

COMPOSITION OF TREES AND SHRUBS.

All vegetable productions may be divided into two great classes. First,

special productions of certain peculiar plants and sometimes of particular organs in those plants. Second, those substances which are always found present in all vegetable life and which make up a greater part of the solid portion of every tree or plant. With the latter division we are to deal and for our purpose we will consider it under two heads; first, those organic constituents that are found in all trees and shrubs during their growth, and second, those mineral constituents that remain after the combustion of the wood of the plant. The organic constituents were always held to be necessary to the growth of the tree while the inorganic, since they varied with the nature of the soil, were thought to be accidental, but this idea has long since vanished and now the mineral constituents are recognized as being of the first importance to the vegetable world.

Prof. Liebig has said "every vegetable requires for its fullest development and the fulfillment of its vital functions the presence of certain organic acids, of the use of which, however, we are ignorant, but farther it also requires that these acids be *in union with a base.*"

It appears from experiment that such substances as (^{soda} Na_2O), (^{potash} K_2O) and (^{magnesia} MgO) can, to a certain extent, act as substitutes for each other, but if it so happens that the supply from the ground is insufficient for the purpose of the tree it cannot thrive unless it has the power of secreting an organic base for its own use, and with trees this is seldom possible. Prof. Liebig further shows that a certain degree of consistency attends the quantity of bases in combination with organic acids present in the same plant grown on different soils, although the proportion of bases may of themselves be very different. An analysis of two pine trees grown under very different conditions showed the quantity of oxygen present in the carbonate to be nearly the same, thus proving that the proportional quantities of organic acids in the two trees must have been united with equivalent quantities of bases. The same was also observed in two fir trees, one of which was grown in Norway and the other in France. The question now arises, Is each of the mineral constituents present in the tree essential to its development? Stohmann has shown by direct experiment that all the mineral food elements have an independent value to the growth of the tree. Potash can not take the place of soda, nor can calcium take that of magnesium. Though they are all necessary for the growth of the tree, for it has been shown conclusively by experimental investigation that the growth of a tree is a function of its *mineral* food elements, they do not all have an equal value as factors of nutrition. The growth of a tree would

therefore always be proportional to the quantity of mineral constituents of nutrition present in the soil in a soluble or available form. This would of course always be more or less influenced by accidental conditions in the surroundings. With the organic constituents of trees we are not to deal, but much has already been done on this subject.

THE WATER IN TREES.

The average amount of moisture in some of the more common trees may be seen from the following:

Ash 28.7 per cent., beech 29, birch 31, elm 44.5, pine 50, oak 40, maple 34, hemlock 45, pear (Howell) 53.7, apricot (Russian) 44.4, cherry (Winslow) 51.8, cherry (May Drake) 50.1, poplar 51.1.

The samples of fruit trees were all taken on the same day, cut fine, dried at 110° C. until constant weights were obtained. The per cent. of moisture is much lower in trees than in grasses, cereals or tubers.

There is a considerable variation in the per cent. of moisture in different parts of the same tree as is shown by the following determination given by Stockhardt. Fir tree cut May 20:

Tree trunk with bark, 36.15 per cent.; thin end of trunk, 50.8; branches over 1 c. m., 47.95; branches under 1 c. m., 51.56; leaves, 52.49.

According to Galesnoff the per cent. of water after increasing from below upwards diminishes again at the summit of the trunk. Not only does the average per cent. of water vary in different parts of a tree but also in the same part there is a variation during different seasons of the year, as shown by the following table also from Stockhardt:

	BEACH TREE.		
	LOWER,	MIDDLE.	UPPER.
Winter	50.5	41.5	39.3
Spring	43.7	42.8	47.
Summer	42.1	44.1	48.
Autumn	39.	40.1	40.1

In ordinary dry wood there is about 15 per cent. of water.

THE ASH OF TREES.

Experiments show that while different trees and different parts of the same tree vary much in their proportion of ash, yet in the same parts of a given species of trees, the quantity of ash remains about the same and its chemical composition though widely varying in different trees is similar for the same parts of the same species, although the soils on which they are grown may differ much in character. Each individual tree seems to make

not only a qualitative but a quantitative selection of the mineral food constituents best adapted to its development. *It does not follow then that out of a given mixture a tree will absorb to the largest extent the mineral constituent that is present in greatest abundance.*

The per cent. of ash found in some of the more common trees and the variations in different parts of the same tree is seen below :

PART OF TREE.	LOWER.	MIDDLE.	UPPER.
Beech wood . . .	.43	.45	.47
Beech bark	3.90	3.30	3.00
Larch wood . . .	.27	.30	.37
Larch bark	1.25	1.75	2.15
Spruce wood . . .	.35	.39	.47
Spruce bark . . .	4.77	4.29	4.53

An analysis of a Larch tree 40 years old gave the following per cent. of ash in its different parts :

Heart wood, .14; Sap wood, .30; last year's ring, .48; Cambium ring, 5.17; leaves, 5.36.

Other trees often contain a much larger per cent. of ash as in the Plum (Malabel) the bark contains 11.2 per cent. while the fruit of the tree contains only .72 per cent.

The following figures will show the per cent. of pure ash as I have found it in some of our common fruit trees, wood and bark of the tree being taken together. The composition of this ash will be found later :

Pear (Howell), .27 per cent. ; Cherry (May Drake), .20 per cent. ; Cherry (Winsor), .23 per cent. ; Apricot (Russan), .22 per cent. ; Poplar, .31 per cent.

It can be clearly seen that there is a marked difference in the per cent. of ash in different trees and in different parts of the same tree. This is also found to vary with the seasons of the year as is seen by the following :

PART OF TREE.	LOWER.	MIDDLE.	UPPER.
Spring Beech wood . . . .	.41	.46	.67
Summer Beech wood . . .	.45	.43	.47
Autumn Beech wood . .	.44	.46	.55
Winter Beech wood . . .	.43	.46	.62
Spring Larch wood . . .	.25	.32	.41
Summer Larch wood . . .	.27	.33	.38
Autumn Larch wood . . .	.25	.26	.33
Winter Larch wood . . .	.29	.36	.41

THE ASH OF LEAVES.

The per cent. of ash in leaves and the variation during the year is worthy of special attention.

The following figures illustrate these points :

Mountain Ash, 6.42 per cent. ; Cherry, 6.70 per cent. ; Beech, 5.21 per cent. ; Maple, 4.68 per cent. ; Elm, 6.82 per cent.

The ash of leaves like that of wood is found to vary during different seasons of the year.

	ROBINIA.	CHERRY.	BIRCH.	CHESTNUT.
May	6.25			6.40
July	7.75	7.30		
September . . .	8.22		4.36	4.75
October	11.74	4.68	7.24	4.55
April		7.80	3.84	

It can thus be seen that the variation in the per cent. of ash in different parts of the tree during the year is very marked; the upper portion being subject to the greatest change. The ash is at its maximum in the sap wood in autumn and winter, and in the heart at its minimum. In the spring the ash in the sapwood falls, at the same time it rises in the bark. By summer both the sapwood and the bark have reached their minimum and the ash constituents go to the leaves. At all seasons of the year however the cambium and bast portions of the tree contain three-fourths of the whole amount. We have every reason to believe that every part of the tree contains a certain invariable amount of mineral matter which is absolutely essential to its existence and that besides this there may be present an inessential and variable amount of the same ingredient. The substances usually found in the ashes of all trees when burned at a low temperature are potash, soda, lime, magnesia and iron (K_2O , Na_2O , CaO , MgO , Fe_2O_3) in combination with phosphoric acid (P_2O_5), sulphuric acid (SO_3) chlorine, (Cl.) carbon dioxide (CO_2) and silica (SiO_2); iodine (I), aluminum (Al.) and manganese (Mn.) are often present. One portion of these mineral constituents exists in solution in the sap and the other in the tissue of the plant in the solid form. In burning, portions of sulphur, chlorine, phosphorus and alkalies may be lost under certain conditions, by volatilization.

The ash remains as the skeleton of the plant, and often actually retains the microscopic structure of its tissues.

THE FORM IN WHICH THE MINERAL ELEMENTS EXIST IN THE PLANT.

If we take a living tree, whose ashes are rich in carbonates of potash, and test its sap, we find instead of the usual alkaline reaction of the salts a strong acid reaction, due to the presence of vegetable acids—oxalic, tartaric, citric or malic, so united with the alkaline potash as to form an acid salt which is held in solution in the sap of the tree. Combustion converts the vegetable acids into carbon dioxide, and the latter unites with the bases.

HOW HAVE THESE SUBSTANCES BEEN ASSIMILATED BY THE TREE?

It must be remembered that the sap of the tree is charged with carbon dioxide and often sodium chloride, therefore the double silicates of ammonia and aluminum in the soil, which are somewhat soluble in such water, are furnished to the tree in sufficient quantities for its development. The silicates of iron are decomposed at ordinary temperature by carbon dioxide. They are, therefore, made soluble in water charged with carbon dioxide and exist in solution in the sap. The alkaline carbonates also bring about many decompositions in the mineral matter of the soil. It is by the introduction of atmospheric oxygen that many of the compounds entering into the double silicates of aluminum are gradually decomposed, and the alkalies—potash, soda and lime, are rendered capable of assimilation and pass in solution in the sap of the tree.

The relative proportion of the constituents of the ash of trees is found to vary in different trees, and also in different parts of the same tree. The following analyses were made of the ash of the young and thrifty shoots which represent a fair average of the proportion of the mineral constituents of the soil that are assimilated by the tree in a year's growth:

	SiO ₂	Fe ₂ O ₃	SO ₃	MgO	CaO	P ₂ O ₅	K ₂ O	Na ₂ O	Total.
No. 1—Pear, Duchess . . . . .	.74	4.29	1.37	10.21	38.52	9.72	30.96	2.71	98.52
No. 2—Pear, Anjou . . . . .	.87	3.15	1.90	9.32	31.88	13.66	26.93	9.60	97.31
No. 3—Pear, Sickles . . . . .	.89	5.14	1.59	1.39	51.20	14.14	25.45	trace.	99.81
No. 4—Pear, Bartlett	2.31	4.18	1.60	2.02	36.15	11.46	29.99	10.74	98.47
No. 5—Pear, Duchess . . . . .	.13	2.14	2.27	8.88	36.03	9.41	35.89	4.01	98.76
No. 6—Pear, Vicar of Wakefield . . . . .	.34	1.39	2.57	43.29	4.96	10.03	37.98	trace.	100.41
No. 7—Pear, Howell . . . . .	.81	5.47	.18	52.93	4.17	20.61	15.78		100.00
No. 8—Plum, Lombard . . . . .	.38	4.35	1.79	2.55	36.89	8.86	31.02	12.43	98.27
No. 9—Plum, Lombard . . . . .	.40	1.21	1.27	5.79	41.40	20.77	24.43	3.86	99.17
No. 10—Plum, Lombard Roots	4.45	3.87	3.48	5.15	29.44	17.00	31.39	4.45	99.32
No. 11—Peach, Late Crawford . . . . .	.97	5.39	2.12	5.84	59.22	7.02	2.19	17.34	100.09
No. 12—Osage, Orange . . . . .	.97	2.28	2.12	4.75	30.10	13.35	34.78	11.06	99.41
No. 13—Cherry, Winslow . . . . .	.65	1.84			54.20	17.64			
No. 14—Cherry, May Drake	1.84	2.21	1.61	3.17	54.20	12.92	.50		76.55
No. 15—Cherry Wood	2.1	.07	3.3	9.2	28.7	7.7	20.8	8.4	
No. 16—Cherry Bark	20.	.2	.8	5.1	42.	3.3	7.5	14.5	.6
No. 17—Apple tree	1.3	1.7	.9	7.5	63.5	4.9	19.2	Na ₂ O.5	100.1

The analyses 1 to 14 were made by myself, and in each case parallels were carried through. The samples for the complete analyses were nearly all taken at the same time, and therefore no variation need be allowed in the different analyses for a change in the per cent. of ash or ash constituents due to its variation at different seasons of the year. The samples being all young and thrifty twigs of one year's growth, the per cent. of ash is consequently low. The analyses 8 and 9 were made from young trees growing a few rods apart; but one sample was taken three months later than the other. The sample for analysis No. 10 was taken from the roots of sample 9. The tree being only three or four years old the whole top was incinerated. The high per cent. of silica (SiO_2) in No. 8 is probably due to the fact that the sample was not thoroughly cleaned, the roots being quite knotty.

In the peach the per cent. of lime (CaO) is higher than for any other tree, but the potash is correspondingly lower.

The variation in the per cent. of mineral constituents in the ash of the two plum trees is quite marked, but this is not strange when we consider the effect of the difference in soil and of difference due to the variation in the time of collecting the samples.

It is quite noticeable that the per cent. of potash (K_2O) in the top and roots of the plum (samples 6 and 8) is nearly the same, while the per cent. of lime (CaO), though varying much, is yet quite low for both root and top. In all of the samples chlorine was found, but not in weighable quantities.

Although at first the variation in the per cent. of ash constituents in the different pears seems strange, it is nevertheless found to be true to experience, for it is well known that land on which some varieties can be grown would not answer for other varieties of the fruit.

It will be seen by the tables that a tree without fruit is not very exhaustive to the land.

The method of analysis was in the main that found in Prof. G. C. Caldwell's Agricultural Chemistry, but some modifications of it were deemed necessary for practical working. The value of these results will be shown by a little explanation.

Subsequent calculations are based on figures given by a prominent fruit grower, modified by experiment and approved by several horticulturists. It is estimated that pear trees such as those from which the samples were taken (six inches in diameter) will add to their growth in a year 10 pounds

of wood above ground, and an equal amount below. Experience shows that the sum of these will not vary more than from 16 to 24 pounds for the total weight of wood added to the entire tree in a year's growth. The trees in question yield on an average 3 bushels of fruit each year, weighing 45 to 50 pounds per bushel. The weight of leaves produced on the same tree is about 20 pounds, and varies in about the same proportion as the wood. The number of dwarf trees (10 by 12 feet apart) on an acre is 363.

The following tables will show the exhaustion of the mineral constituents of the soil by weight in pounds, in the yearly growth of wood above ground on an acre of orchard in which the arrangement of trees is as above indicated :

The pure ash of the wood of the pear we found to be .27 per cent.

	S ₂ O ₃	SO ₃	Fe ₂ O ₃	CaO	MgO	P ₂ O ₅	K ₂ O	Na ₂ O
No. 1—Pear, Duchess . . . .	.07	.13	.43	3.88	1.03	.98	3.11	.27
No. 2—Pear, Barre Anjou . .	.09	.19	.34	2.22	.93	1.38	2.68	.98
No. 3—Pear, Sickles . . . .	.09	.16	.52	5.17	1.40	1.43	2.57	. . .
No. 4—Pear, Bartlett . . . .	.23	.16	.42	3.65	.20	1.16	3.02	1.08
No. 5—Pear, Duchess . . . .	.01	.23	.22	3.64	.90	1.20	3.63	.40
No. 5—Pear, Vicar of Wakefield	.34	.11	.26	4.47	.5	1.01	3.83	
							cl'ds by diff.	
No. 7—Pear, Howell . . . . .	.08	.02	.55	5.35	.42	2.08	1.59	
No. 8—Plum, Lombard . . . .	.14	.67	.16	1.38	.56	.83	1.16	.47
No. 9—Plum, Lombard . . . .	.15	.45	.49	1.53	.22	.78	.90	.15
No. 10—Plum, Lombard Roots	.17	.13	.15	1.1	.19	1.18	.16	.64
No. 11—Peach, Late Crawford .	.03	.07	.13	1.6	.16	.21	.48	.06

These tables give quite an accurate idea of the amount of mineral constituents a tree takes from the soil and also of the exhaustion of orchards to the land.

The amount of lime (CaO) taken up by the trees on an acre varies from 3.6 lbs. to 5.3 lbs. The potash (K₂O) from 2.5 lbs. to 3.6 lbs. and the variation in the other mineral constituents taken from the soil can be seen in the tables. The Bartlett pear is the least and the Sickles pear the most exhaustive to the land. Plum trees are not one-half so exhaustive as pears while the peach tree is less exhaustive than either.

The figures regarding the number of trees on an acre, also the yield of fruit per tree and its weight, are taken from Prof. Bailey's Horticulturist's Year Book. The weight of wood added to a standard pear tree is five times that added to a dwarf tree, but the number of trees on an acre is one-fifth as many, therefore the exhaustion to the land would be about the same. It is interesting to compare the amount of mineral constituents required for the yearly growth of trees, with that necessary for some of the more common field crops.

The following analyses were made by Thos. Way and G. H. Ogston and will give an idea of the drain upon land which is used for cereals, hay, &c. Pounds per acre:

CROPS.	SiO ₂	P ₂ O ₅	SO ₃	CaO	MgO	Fe ₂ O ₃	K ₂ O	Na ₂ O	NaCl	KCl
Oats	69.8	22.3	5.8	12.	9.1	2.7	36.5	3.6	3.8	6.3
Barley	107.2	24.3	4.3	15.6	8.8	1.6	38.3	2.6	.6	.7
Hay	184.7	57.3	31.3	74.	19.7	7.4	273.3	.3	21.1	77.8
Flax	22.1	25.6	8.2	51.1	12.1	9.7	59.5	6.	18.3	2.2
Hops	47.6	28.4	6.6	60.4	11.4	.9	44.6	none	6.1	15.0
Corn	36.4	31.4	6.5	18.5	12.4	3.	56.6	.9	.3	none.

It must be remembered that there is added to the roots of a tree an amount of wood equal to that added to the top, the composition of which as compared with the top may be seen in analyses Nos. 9 and 10, but since the wood of the root is never taken from the ground the mineral constituents which are a part of its composition can never be said to be taken from the field, yet in a growing tree the fact must be remembered and a rate of exhaustion allowed for the roots equal to that of the branches.

There is also taken up by the leaves an amount of mineral constituents, the per cent. of which is shown by the following table taken from Dr. Wolff's ash analysis.

	LEAVES OF				
	APPLE.	CHERRY.	BEECH.	MAPLE.	ELM.
K ₂ O	24.75	23.23	21.83	25.41	23.67
Na ₂ O	2.67	9.60	3.26	.93	2.16
CaO	53.39	42.64	44.37	30.89	29.31
MgO	5.56	12.33	7.29	10.49	8.41
Fe ₂ O ₃	1.08	.91	2.37	1.98	6.86
P ₂ O ₅	6.71	6.36	7.83	9.56	7.63
SO ₃	3.32	2.21	2.49	9.67	2.05
SiO ₂	2.31	2.73	10.56	11.07	19.91
CO ₂	22.02	23.29	11.59	14.08	11.38

Much of this material, however, returns to the land and need not be considered as very important in the calculations.

The only part of the mineral constituents absorbed by the tree that are carried away from the field is that portion contained in the fruit. The amount of fruit grown on different trees varies within such wide limits and its mineral constituents vary so much with the quality of the fruit that only very general conclusions can be given.

The results below, taken from Dr. Wolff's ash analysis, show the composition of the ash of some of the common fruits:

	FRUITS.			
	APPLE.	PEAR.	CHERRY.	PLUM.
K ₂ O	35.68	54.69	51.85	59.21
Na ₂ O	26.09	8.52	2.19	.54
CaO	4.08	7.98	7.47	10.04
MgO	8.75	5.22	5.46	5.46
Fe ₂ O ₃	1.40	1.04	1.98	3.20
P ₂ O ₅	13.69	15.20	15.97	15.10
SO ₃	6.09	5.69	5.09	3.83
SiO ₂	4.32	1.49	9.04	2.36
Cl			1.35	
Pure ash	1.44	1.97	2.20	1.87

These results give the amount of mineral constituents an average growth of fruit takes from the soil. The following statements, together with the previous calculations, serve as a basis in the determination of the results given in the table which follows :

APPLES.

Every alternate year a full grown tree produces 30 bushels weighing 48 pounds per bushel. There are on an average 20 trees on an acre.

CHERRIES.

The average yield of a cherry tree is 5 bushels, and the weight of a bushel 40 pounds. There are 135 trees on an acre.

PLUMS.

The average yield of a plum tree is 6 bushels, and the weight of a bushel is 55 pounds. There are 135 trees on an acre.

PEARS.

The average yield of a dwarf tree is 3 bushels, and the weight of a bushel is 48 pounds. There are 363 trees on an acre.

	K ₂ O	Na ₂ O	CaO	MgO	Fe ₂ O ₃	P ₂ O ₅	SO ₃	SiO ₂	Cl
Apples.									
Single tree	7.39	5.41	.84	1.81	.29	2.83	1.26	.89	
Acre	147.9	108.1	16.92	36.28	.58	56.76	25.25	18.29	
Cherries.									
Single tree	2.28	.69	.33	.24	.08	.70	.22	.39	.05
Acre	308.	.12	44.58	32.43	11.76	94.86	30.23	53.69	8.01
Plums.									
Single tree	3.55	.03	.60	.32	.19	.90	.23	.14	
Acre	480.	4.37	81.39	44.27	25.94	122.	31.	19.14	
Pears.									
Single tree	1.55	.24	.22	.14	.02	.43	.16	.04	
Acre	563.1	87.72	82.17	53.75	10.71	156.5	58.5	15.34	

We next consider the per cent. of nitrogen found present in trees, and also its variation in the different parts of the same tree. The following

table is from Dr. Wolff's Aschen Analysen, and shows the variation in the fir tree :

	LOG WOOD.	BILLET WOOD.	BRANCHES.	END OF BR.
Wood . . . . .	.11	.11	.17	.68
Bark . . . . .	.65	.59	.67	1.10
Sap . . . . .	.17	.18	.32	.78

The variation during different parts of the year is also given :

	TREES—CHERRY.	BIRCH.	PINE.	CHESTNUT.
April	2.00	. .	. .	. .
May . . . . .	. .	. .	3.59	2.12
June . . . . .	. .	2.43	. .	. .
July . . . . .	.95	2.32	2.81	. .
August . . . . .	. .	1.57	. .	. .
September . . . . .	.84	1.28	1.68	.70
October . . . . .	.11	.49	.70	.62

The table represents the per cent. of N in wood dried at 100°C.

The source of the mineral constituents of the trees must be the soil, while the atmospheric carbon dioxide, water and ammonia, furnish the organic compounds which enter into the growth of trees. The H used by the tree comes from the water, the carbon from the carbon dioxide and the nitrogen from ammonia. There appears at present to be but little certain knowledge as to the power of trees to absorb combined N directly from the air as distinguished from that obtained from the same source through the agency of the soil. The organic materials used by trees are the remains of animals and plants, but even these must assume the mineral form before they can become food for trees. The other mineral constituents are absorbed from the soil by the roots, after being first made soluble by the decomposition going on in the soil, which renders them capable of being taken up by the sap and distributed to all parts of the tree. NH₃ is of the first importance to the vegetable world, and for its retention in the soil four alkaline bases are made responsible. It is, therefore, always present in an available form. Usually enough ammonia and nitric acid are present in the atmosphere for vegetation, and by cultivation and accumulation may take place in the soil. The mineral constituents necessary to the growth of the tree are potash, lime, magnesia, and iron, phosphoric acid, sulphuric acid, with possibly the addition of soda.

The analyses of Bibra, Zoeller, Arendt, Bretschneider and others upon the per cent. of soda in trees and plants leads to the conclusion that in

some trees, or in certain parts of trees, it may be wholly wanting, while in others it may occur in abundance. It has not been proven, however, that soda is entirely wanting in any entire tree or plant grown on natural soil. The general conclusion is, then, that the quantity of soda present in a tree is an extremely variable one, and though generally present in some proportion, yet in some parts of a tree it has not been found present in weighable quantities.

An important question now arises: Can soda take the place of potash? The result of the investigations of Halm-Horstmar, and more recently of Knop and Schreber, have demonstrated that it cannot entirely do this, since potash is absolutely essential to the growth of the tree. Cameron concludes that soda can partially replace potash, and this appears to be indicated by many facts. It may be, however, that the soda which often appears to replace the potash is accidental, and that the replaced potash was present in the tree in an excess of that really needed for its growth. The amount of either absorbed would depend on the nature of the soil.

Potash is of the next importance to the vegetable world. The organic acids require alkalies and alkaline earths to form the salts which exist in the tree, and in most cases it would be impossible for these acids to be formed were it not for the presence of these bases. There is every reason to believe that the alkalies are peculiarly connected with the formation of carbohydrates, and that an increased assimilation of alkalies is co-ordinate with the increased formation of carbohydrates.

Lime is of the next importance. Its great abundance in nature is a guarantee of its presence in an available form for the tree.

Of the remaining ingredients, iron, is perhaps, of the greatest importance. It is abundantly proven that its presence is necessary to the development of the tree or plant. It is usually found in the greatest abundance in the bark; much of it is accidental and not necessary to the development of the tree.

Cl is never totally absent from a tree, but if necessary to its development, only a small quantity is needed. Its absence in many reported analyses is due, without doubt, to the fact that it is easily driven off from the ash when it is at the temperature necessary for the combustion of the wood.

Silica is not indispensable to the growth of trees but analyses show that it is always present in the ash of trees grown on natural soils. It is usually

found most abundant in the stem and sometimes occurs to the extent of 30 per cent., as is often the case in the pine tree. It also varies greatly with the age of the tree, and is frequently found as a coating on the bark. Halm-Horstmar's investigations seem to indicate that silica is indispensable to vegetation, but the later investigations of Sachs, Knop, Nobbe, Stiegert, Wolff and others, indicate that it is not essential to the physiological development of the plant. Its great abundance in the soil, however, accounts for its occurrence in the ash of all trees.

Lucanus' investigations show conclusively that the oxide of manganese is inessential to the development of the tree.

It must be remembered that all the ash constituents which are necessary to the growth of the tree may be absorbed by it in a much larger quantity than is essential.

The effect of an abundance of any one of the ash constituents of a tree upon its vegetable products has been given some study, but no definite conclusions have been reached. It is known, for example, that pears will flourish on ground that would yield apples scarcely palatable, but the mineral constituent wanting and necessary for the full development of the apple is not known.

Fruit growers agree that by the use of fertilizers you may affect the growth of wood very much, but not the quality or quantity of fruit. The best form to apply the mineral constituents to the soil is in the use of stable manure which has the following average composition: Water 75 per cent., organic matter 19.2, ash 5.2, nitrogen .5, potash .63, soda .19, lime .7, magnesia .18, phosphoric acid .26, sulphuric acid .16, silica .16, chlorine and fluorine .19.

The composition of the ash of trees certainly does not of itself afford sufficient data to determine, with anything like certainty, which fertilizing constituents or manuring mixtures should be applied to the various trees in order to produce the largest yield of fruit. A knowledge of the composition of the ashes of trees, however, gives us warning that our trees will become unhealthy if the soil on which they are grown is either wanting or contains insufficient quantities of one or more of the ash constituents necessary for the growth of the tree. Often the amount of growth is sought to be increased by the addition of ammonia when really the soil may be starving for mineral food. An excess of ammonia over the proper proportion of mineral constituents does not enter into the growth of the tree, or in other words, as before stated, the increase in growth in a tree is propor-

tional to the mineral elements of nutrition present in the soil in a soluble or available form, and an excess of ammonia will not supply this deficiency. The aim should be to apply enough and just those elements that will increase assimilation of mineral constituents. Often the increase of mineral food may prove effectual far beyond the increase of nitrogenous matters, but the effect will depend most closely upon the amount of CO_2 and solar energy available for use, and the reverse must be remembered, solar energy is limited by the amount of soil materials present. Endeavor also to use salts of those acids which are present in the least quantity in the soil. The effect of the addition of ammonium salts is not what NH_3 would be, for they contain an acid which acts on the constituents of the soil and renders the earthy phosphates more soluble in water.

Experiment shows that trees die if the supply of mineral food is exhausted, even though they be still supplied with organic food in abundance. It must be remembered that the roots of trees go down deep in the soil and bring to the surface much that would not be available were ordinary crops grown on the field.

An experiment made by George Ville will show the effect of fertilizers upon vegetation. The plant taken for the investigation was hemp. The characters of the plant taken into consideration are color, stature, weight: "Seven soils were used. First, intense manure (100 kilos of N); second, complete manure (75 kilos of N); third, manure without nitrogen; fourth, manure without phosphates; fifth, manure without potash; sixth, manure without lime, and, seventh, soil without manure. Plants treated with intense manure were of the deepest green, height 1.25 metres, weight 11.22 kilos; complete manure, height 1.20 metres, weight 11.15 kilos, color less deep; manure without N, height .61 metres, weight 4.74 kilos, color yellowish green; manure without phosphates, height .97 metres, weight 8.22 kilos, color medium green; manure without potash, height .40 metres, weight 5.22 kilos, color light yellowish green; manure without lime, height 1.15 metres, weight 10.57 kilos, color slightly paler than those without phosphates; plants in unmanured soil, height .18 metres, weight 2.17 kilos, color pale green."

This experiment gives us a fair knowledge of the effect of different fertilizers, and may be of some aid in the selection of those intended to be used on orchard land.

The object of this investigation has been to place at the disposal of the fruit grower some definite knowledge of the drain upon his orchard land

and also to give him an idea of how much and what mineral constituents he must apply from year to year to meet the demands of a thrifty tree.

The writer is indebted to Prof. G. C. Caldwell, of Cornell University, for the material and assistance that enabled him to carry on this investigation

POISONOUS EFFECTS OF *CYPREPIDIUM SPECTABILE*. By D. T. McDOUGAL. Published in the Minnesota Botanical Studies, Part I; 32-36.

SYMBIOSIS OF *ISOPYRUM BITERNUM*. By D. T. McDOUGAL. Published in the Minnesota Botanical Studies, Part II; 139-142.

THE STOMATES OF *CYCAS*. By MASON B. THOMAS.

OUR PRESENT KNOWLEDGE OF THE DISTRIBUTION OF PTERIDOPHYTES IN INDIANA.
By LUCIEN M. UNDERWOOD.

The purpose of this paper is not primarily to convey any new information although it contains reference to some plants not hitherto reported from this state; nor for the purpose of criticizing what has hitherto been accomplished though it notes the necessity of cutting out some of the plants reported from the state that never belonged to its flora. Its purpose is rather to indicate the paucity of information we have at hand regarding the distribution of even the best known groups of plants; to indicate the extensive portions of the state that are practically untouched by the hand of the collector; to indicate how futile and useless it is to publish or even make manuscript lists of the plants of any region and leave nothing to represent this information aside from a mental recollection or a printed or written line; to outline the limits of our definite in-

formation and to indicate the directions in which future observations may be made useful if accompanied by vouchers that will enable one to verify the accuracy of the information at any future time.

The fern flora of Indiana seems meagre to one familiar with the profusion that is manifested in many other parts of the country. For ferns to flourish there must be more uniformity of moisture, and less irregularity of season than have been manifested in this state in recent years. A climate interrupted by long periods of drought, swamps that lose their water during summer, a soil that is constantly being gullied by rains that flow away quickly from the surface, or areas that are likely to be covered by the alluvium of rivers at times of high water—these are not the conditions under which ferns reach a high state of development in either luxuriance or variety. The ravines along the streams where some moisture is always present, furnish the richest stations where ferns may be found within our limits; permanent swamps will also furnish their quota but the variety is there less than the profusion of certain species.

There are just 50 species of Pteridophytes that now stand on the state list either verified or with more or less probability of verification. Of these, thirty-three are members of the order Filices, and the remaining seventeen are distributed among the five related orders. Of the fifty species, we have verified, either by consultation of accessible herbaria or by personal collection during the past season, all but ten, as follows: *Onoclea Struthiopteris*, *Phegopteris dryopteris*, *Cheilanthes vestita*, *Equisetum sylvaticum*, *E. laevigatum*, *E. robustum*, *E. variegatum*, *Lycopodium obscurum*, *L. inundatum*, and *Selaginella rupestris*.

Certain species have been credited to the state that were based on errors of determination. Among these *Dryopteris Filixmas* (*Aspidium*) is most prominent; this has been variously confused with *D. Noveboracensis* and especially with *D. spinulosa*. Its range from Lake Superior northward precludes its being found in Indiana. *Phegopteris polypodioides* was asserted by one correspondent to be found in Jefferson county and he reinforced his statement by the announcement that the plant had been determined at Cambridge. On sending for the plant I found it to be only a young plant of *P. hexagonoptera*, and not a very complete specimen at that. *Lycopodium Selago* was reported by two collectors from Putnam county, but the plant growing there is *L. lucidulum*, of which the rock forms bear a more or less striking resemblance to that alpine species. *Botrychium lunaria* as printed in the list of plants of Dearborn county was a

misprint for *B. lunarioides*, as I learn from Dr. Collins himself.

Cheilanthes vestita was placed in the state list from Gibson county, presumably on the authority of Dr. Schneck's Wabash flora, but in a recent letter Dr. Schneck informs me that it does not grow in his vicinity but farther to the southwest in Illinois. There is therefore no certainty that it belongs to our flora.

The only other doubtful plant is *Equisetum sylvaticum*, which seems out of place in southern Indiana. No specimens of the original collection were saved as is too commonly the case in the construction of local floras.

The published state catalogue* may be taken as a datum line for further reports; the additions to the state flora since its publication are as follows:

1. *Dryopteris spinulosa intermedia* (Muhl) Underw. Was first collected and identified by W. S. Blatchley, in Monroe county, and later in Vigo county. G. C. Hubbard collected it in Putnam county, where it is not uncommon.

2. *Asplenium ebenoides* R. R. Scott. A single spond of this species (separate from the main specimen) occurs in the Wabash College herbarium collected in Jefferson county, by J. M. Coulter. It is a rare fern and by many is regarded as a hybrid. It should be sought where its supposed parents, *Camptosorus* and *Asplenium platyneuron*, occur.

3. *Equisetum laevigatum* A. Br. Is reported by Rev. E. J. Hill, from Lake county, and its distribution is likely to be more extensive, as it might be confused somewhat easily with *E. hyemale*, which is widely distributed.

4. *Lycopodium lucidulum* Michx. Was first collected by G. C. Hubbard and D. T. McDougal, at Fern, Putnam county. It is somewhat common in the ravines at that place.

The following species, which appear in neighboring states, are to be looked for in this state:

Cheilanthes gracilis (Fee) Mett. (*C. lanuginosa*) Illinois.

Woodwardia areolata (L.) Moore. (*W. angustifolia*) Michigan.

Dryopteris cristata (L.) A. Gray (Rang includes Indiana.)

Asplenium montanum Willd. Ohio, Kentucky.

Botrychium matricariaefolium A. Br. Ohio. There would seem to be no reason why this and some of the other small species of *Botrychium* should not be found in this state. They are small and often grow in grassy woods and are, therefore, easily overlooked.

*Catalogue of the Phaenogamous and vascular cryptogamous plants of Indiana, by editors of the Bot. Gazette and C. R. Barnes, 1881.

Lycopodium clavatum L. May occur on some of the higher land of the state, though its distribution is, in general, more northerly.

Species of *Isoetes* should be found, especially in our northern lakes.

Turning, now, to the counties from which plants of this group have been reported we find that from only 31 counties have we any information whatever and from a number of these only one, or at most, a few common species. From a half dozen we have reasonably full returns and these are mostly those in which a college is located at the county seat. Jefferson leads with 31 species, followed by Putnam and Monroe with 27 each. Clark stands next with 22 and the rest are 20 or mostly much less. It will thus be seen that fully two-thirds of the counties of the state have not been explored botanically and represent the regions into which missionary work should be organized by the Survey. Of those that have been explored, certainly less than a dozen are even fairly well known in their higher or vascular flora.

The distribution of certain species has more than a local interest; this is specially true of those which reach their northern or southern limit in the state. Of these *Polypodium polypodioides* (*P. incanum*) is an example of southern form whose northern range in Indiana as known at present is in the counties of Posey, Gibson, Perry, Floyd, Clark and Jefferson. It is not unlikely that this range will be considerably extended as soon as some one with a sharp eye goes into the other counties of the southern tiers. It is an epiphytic fern growing on oaks and probably other trees. *Asplenium pinnatifidum* is another southern fern which so far has been found only in Gibson county. Of the northern species, *Woodwardia Virginica* is only found in Lake and LaPorte counties and will probably not be found far from the borders of the great lake. *Selaginella rupestris* is at present known only from Lake county,* though its limits are likely to be much extended. The various species of lycopodium are likely to show limited northern range, though *L. complanatum* has been found since the publication of the state catalogue in the counties of Putnam and Monroe, but always on the northern exposures of the hills. The further stations of any of our lycopodiums is a matter of more than local interest. Among other species that seem to have a restricted range we have *Onoclea struthiopteris* reported only from Montgomery, *Phegopteris dryopteris* from Allen, and *Asplenium*

*The reference in the state catalogue to Gibson county proves to be an error, as the plant thus referred to turns out to be a hepatic. The Montgomery county station also needs verification.

ebenoides from Jefferson. While all these need further verification, there is no reason apparent why they should be thus limited, though the last named species is always a rare and local find.

In preparing this paper the following herbaria have been examined: Purdue University, containing 22 Indiana species, many collected by Dr. C. R. Barnes, in Jefferson county; the herbarium of G. C. Hubbard, with 24 species, collected mostly in Southern Indiana; that of Wabash College, with 25 species, largely collected by Dr. J. M. Coulter; that of DePauw University, with 29 species, collected by D. T. McDougal in Putnam and by W. S. Blatchley in Monroe and Vigo; and that of the writer with 35 Indiana species collected in various parts of the state, mostly during the present season.

Valuable notes have also been sent by Rev. E. J. Hill, Dr. J. Schneck, W. P. Shannon, W. S. Blatchley and Professor A. H. Young. It is hoped that the work of a second season will give more definite and fairly complete information regarding the distribution of critical species.

THE ADVENTITIOUS PLANTS OF FAYETTE COUNTY, IND. By ROBERT HESSLER.

During the period from 1881 to 1890 the writer kept a close watch upon the flowering plants of Fayette county, noticing particularly the arrival of plants commonly regarded as weeds. During those ten years there were at least thirty-five new arrivals; of these twenty appeared along the railroads, ten along roadsides and waste places, four in meadows, one in a cultivated field. Of the thirty-five, seven again disappeared after a year or two, eighteen merely held their own or spread only to a limited extent, while ten have swept across the county and may now (*i. e.*, 1890) be found almost everywhere.

A brief note on the main features of the county may aid in better understanding the changes in the flora. Fayette county is almost due east of the capital and is the second county from the Ohio state line. The county was formerly densely wooded. The surface, excepting the level northwest portion, is rolling and in places even hilly, especially along the southern boundary. The whole surface is covered by drift. The county is divided from north to south by a broad valley through which the White Water

river flows. The valley has a black, gravelly soil of great fertility. The White Water railroad traverses the county from north to south; the Lake Erie & Western goes north from Connersville. The Cincinnati, Hamilton & Indianapolis crosses the county from east to west, and crosses the W. W. R. R. at Connersville, and at a different level. I mention this fact because it has some bearing on the distribution of weeds.

In the following notes the plants are given in the order of arrival by years. The first two years are grouped together, as my notes do not allow me to differentiate. At that time I did not get over the county so much as in after years, and some of the plants may have appeared a year or two before this date. After the year 1882 I traversed the ground so frequently that I am sure the dates given for the arrival of new species are correct. The nomenclature is that of the last revised edition of Gray.

The following nine plants were seen during the years 1881 and 1882, that is, when I first began botanizing systematically.

Echinosperrum Lappula, seen along the W. W. R. R. near Connersville. The patch has increased only slightly, not inclined to spread much.

Arenaria serpyllifolia, a small plant first seen along the W. W. R. R. below town. Now very common in sandy or gravelly soil. Not given in Coulter's catalogue of the plants of Indiana.

Potentilla Norvegica, occasionally seen in meadows, and is now rather common.

Medicago lupulina, seen along the C., H. & I. west of town, is now frequently seen along the railroads and roadsides.

Dysodia chrysanthemoides, seen in the locality near the last, and is now common throughout the county.

Geranium Carolinianum, along the W. W. R. R. below town, and now along the whole line.

Verbena officinalis, along roadsides west of town, now frequently seen in the valley.

Montelia tuberculata (var. *subnuda*), first seen along the C., H. & I. R. R. east of town, now common along that road and frequent in the valley.

Croton monanthogynus shows the rapid spread of a new arrival. In 1882 a small patch was first seen a few miles below town in an isolated meadow near a creek. The next year it appeared along the W. W. R. R. Two years later it could be found throughout the White Water valley, or wherever there was dry gravelly or sandy soil.

Beginning with the year 1883 I can give a definite date for each species.

As I have already stated, I went over the ground so frequently that I am sure the plants did not exist before the date given. The only exceptions to this statement are in the case of the *Balm* and *Poison Hemlock*, these grew in isolated places not frequently visited.

1883.

Cassia Chamaecrista, appeared along the W. W. R. R. south of town, now frequent along all the railroads.

Chrysanthemum leucanthemum, the Ox-eye daisy, in a meadow near town, now frequently seen.

1884.

Lactuca scariola, a rank weed, W. W. R. R. in city, spread rapidly along this railroad and is now very common along it.

Nicandra physaloides, appeared in a corn field near the railroad south of town, disappeared, again reappeared in 1888 and again disappeared.

Eragrostis major (and perhaps also *E. minor*), the only addition in the grasses appeared along the W. W. R. R., above town.

1885.

Gaura biennis in a waste place near town, now occasionally seen along the W. W. R. R.

Verbena bracteosa, along roadsides east and west of town, mainly on uplands, seldom seen in the valley.

Lithospermum arvense, the so-called Wheat-thief, along W. W. R. R., south. All plants seen were destroyed, but it reappeared the next year. Now common along the railroads, but as yet rare in fields or meadows.

Solanum Carolinense, seen along the C., H. & I. R. R., east, and destroyed; none seen for two years. It is now frequently seen.

1886.

Melilotus alba, the sweet clover, appeared along the C., H. & I. R. R., west of town. It is now a very common and rank weed.

Solidago lanceolata, along roadsides just west of town; not inclined to spread.

Rudbeckia laciniata, a tall cone-flower, appeared in the valley, and is apparently just holding its own; is not spreading.

Melissa officinalis, the Balm, is no doubt an escape from a garden. Not spreading.

Verbena stricta, first seen along the W. W. R. R., south of town; now frequent along this road and occasionally seen along the other railroads.

1887.

This year was the banner year for new arrivals, as nine new species appeared.

Conium maculatum, a few individuals of this rank poisonous plant were seen near a dwelling in an isolated region. I do not know its ultimate fate. No other specimens were found.

Saponaria vaccaria appeared in considerable numbers west of town along the C., H. & I. R. R. This is an annual plant. It appeared for one season only.

Enothera sinuata, a few plants were found a few miles east on the C., H. & I. R. R. Three years later it had entirely disappeared.

Gaura coccinea, a far western species, appeared near the last, and after a few years died out.

Rudbeckia speciosa, a small patch of this showy cone-flower was found in a wet meadow away from all lines of travel. This patch is gradually increasing and when in full bloom presents a beautiful appearance. This plant is not reported in Coulter's Catalogue.

Cnicus arvensis, the Canada thistle, appeared at the C., H. & I. R. R. station. The attention of the railroad company was called to the presence of this pest and all specimens were thoroughly destroyed. It has not been seen since.

Plantago lanceolata had been frequently seen in the county below us, but not until 1887 did we find it in Fayette county. It is now a very common weed.

Euphorbia dentata, a few plants appeared for a season along the W. W. R. R., a mile or two below town. Has disappeared entirely.

Hypericum perforatum, a single plant was found along a roadside west of town; it was destroyed at once.

1888.

Melilotus officinalis, the yellow sweet clover, appeared along the C., H. & I. R. R., in town.

1889.

Plantago Virginica was found quite abundantly along the Ft. Wayne R.R., and the next year was quite common along all the railroads in the valley.

1890.

Very little botanizing was done this year and only one new species was found. Two or three specimens of the false flax, *Camelina sativa*, appeared along the W. W. R. R. below town.

NEW PLANTS NOW COMMON.

Out of the thirty-five new arrivals, the following nine have taken the county by storm—that is, they are now very common:

<i>Arenaria serpyllifolia.</i>	<i>Lactuca scariola.</i>
<i>Croton monanthogynus.</i>	<i>Melilotus alba.</i>
<i>Dysodia chrysanthemoides.</i>	<i>Plantago Virginica.</i>
<i>Chrysanthemum leucanthemum.</i>	<i>Plantago lanceolata.</i>
<i>Lithospermum arvense.</i>	

SOME EVOLUTION AMONG CACTI. By JOHN M. COULTER.

[ABSTRACT.]

The nascent tubercles of *Eumamillaria*, *Coryphantha*, *Echinocactus*, *Ana-halonium* and *Lophophora*, show in their generic characters perfectly intergrading characters, which serve to clear up certain homologies and relationships.

PHYSICS AND CHEMISTRY.

PERMANGANIC ACID. By THOS. C. VAN NUYS AND SHERMAN DAVIS.

It is the purpose of this investigation to work out, if possible, I. The exact conditions under which permanganic acid or its salt undergoes spontaneous decomposition. II. Whether it is effective as an oxidizing agent in the decomposition of organic matter.

I. For determining the exact properties of the acid or its salt, the following plan was adopted. Glass tubes, about 30 mm. and 30 cm. long were sealed at one end and carefully annealed. They were then filled with a strong H_2SO_4 sol. of potass. permanganate and heated to $100^\circ C.$ for 12 hrs. This treatment completely removed any organic matter adhering to them. The distilled water was purified by boiling a strong H_2SO_4 sol. of potass. permanganate, with a condensing apparatus, for some time and then distilling the second time with $KMnO_4$. The $NaOH$ used in making the standard alkali sol. was prepared from the pure metal and absolutely pure water. The tubes were then carefully rinsed with the C. P

water and made ready for use. After introducing a definite quantity of the standard sol. of potass. permanganate from a burette, graduated to $1\frac{1}{10}$ cc, and a definite amount of the acid or alkali, the tubes were sealed, then cooled gradually to anneal them. When cold, the tubes were well shaken to mix the fluid and then introduced into a copper bath 4 in. wide and 15 in. long. When working at 100°C. pure water was used to fill the bath; for higher temperatures aniline was used. We found aniline preferable to paraffin because the heat diffused through it more readily and uniformly. Many conditions were tried to determine if possible all the factors which enter into the problem. From the data obtained there seem to be four primary factors which influence the spontaneous decomposition of permanganic acid. 1. The quantity and kind of acid or alkali used. 2. Time of heating. 3. Temperature. 4. Dilution. This is shown by the following data: I. Quantity and kind of acid used:

	No.	$\text{SO}_3 \frac{n}{n}$	KOH	$\text{KMnO}_4 \frac{n}{10}$	Oxalic A.	KMnO_4	Time	Water.	Per cent. Dec.
100° C	1	2	x	10cc	12.00	2.25	2 hr	8cc	3.2
	2	2	x	10cc	12.00	2.35	2 hr	8cc	
	3	2	x	10cc	12.00	2.22	2 hr	8cc	
	4	2	x	10cc	12.00	2.20	2 hr	8cc	
	5	2	x	10cc	12.00	2.25	2 hr	8cc	
	1	1cc	x	10cc	12.00	2.20	2 hr	9cc	1.8
	2	1cc	x	10cc	12.00	2.20	2 hr	9cc	
	3	1cc	x	10cc	12.00	2.15	2 hr	9cc	

Orthophosphoric acid shows less decomposition.

II. A. Time of heating.

	No.	$\text{SO}_3 \frac{n}{n}$	KoH	$\text{KMnO}_4 \frac{n}{10}$	Oxal. A	KMnO_4	Time.	Water.	Per cent. Dec.
	1	2cc	x	10cc	12.00	2.20	1 hr	8cc	1.6
	2	2cc	x	10cc	12.00	2.15	1 hr	8cc	
	3	2cc	x	10cc	12.00	2.20	1 hr	8cc	
	4	2cc	x	10cc	12.00	2.15	1 hr	8cc	

By using 4-6-8cc of acid with constant time, temp. and dilution, we find the per cent. decomposition is almost exactly proportional to the quantity of acid used. It may be represented by the curve A.

By using constant acid and dilution and temp. the per cent. decomposition is approximately proportional to the *time* of heating. Its curve is therefore the same as that for the acid decomposition B. with NaOH.

The NaOH sol. of permanganic acid is much more stable under like conditions than the H_2SO_4 sol. This is shown by the following data:

	No.	NaOH	KMnO ₄	Oxal. A.	KMnO ₄	Time.	Water.	Per cent. Dec.
100°C	1	2cc	10.00	12.00	2.07	1 hr	8	0.2
	2	2cc	10.00	12.00	2.02	1 hr	8	
	3	2cc	10.00	12.00	2.00	1 hr	8	
	1	4cc	10.00	12.00	2.05	1 hr	8	0.7
	2	4cc	10.00	12.00	2.12	1 hr	8	
	3	4cc	10.00	12.00	2.05	1 hr	8	
		6	10.00	12.00	2.05	1 hr	8	0.2
		6	10.00	12.00	1.95	1 hr	8	
		6	10.00	12.00	2.01	1 hr	8	
		6	10.00	12.00	2.05	1 hr	8	

From these data we see that the amount of decomposition is within the limit of error in manipulation, for the time and temp. used.

By increasing the time to 2 hr. and dilution to 50cc there is no appreciable increase in the amount of decomposition.

If the temp. be raised to 175°C, the other conditions remaining constant, the dec. rises to 2 per cent.

	NaOH	KMnO ₄	Oxal. A.	KMnO ₄	Time.	Dil.	Temp. 175°
1	6	100	12.00	2.20	1 hr	34	Per cent. 2.75
2	6	100	12.00	2.20	1 hr	34	
3	6	100	12.00	2.20	1 hr	34	

In all these cases we have used a $\frac{1}{10}$ Nor. sol. KMnO₄; if $\frac{1}{100}$ be used the decomposition especially with H_2SO_4 is much greater.

II. In studying the oxidation properties of the NaOH sol. we followed the outline given by Lentz. We find that by using a Nor. sol. NaOH, a $\frac{1}{10}$ Nor. KMnO₄ Sol. and diluting to a definite volume—100cc—the oxidizing properties of this acid is much greater than shown by him. We succeeded in oxidizing 97 per cent. of a standard sol. of grape sugar, even under secondary conditions and obtained constant results in each case. The work on oxidation has not been developed, but it appears from what has been done, that this method with the standard NaOH sol. and the sealed tube can be made to completely oxidize such substances as sugar and glycerine.

DETECTION OF HYDROCYANIC ACID IN TRACES. By THOS. C. VAN NUYS AND SHERMAN DAVIS.

The detection of HCN in traces in the presence of hydroferro- and hydroferricyanic acid, according to the method of Otto, is attended with many difficulties. In our laboratory practice we have failed to find it sufficiently delicate and reliable. The distillation at 50, 60, or even at 80 per cent. often fails to drive over the free *hydrocyanic acid*. As a substitute for this method we cheerfully recommend the following method:

I. When a large quantity of organic matter in a *coarse* condition is present, introduce it into a fine-meshed silk seive. Moisten it all over with a 10 per cent. sol. tartaric acid and wash into a 500cc. cylinder, glass stoppered, with distilled water, until the total vol. amounts to 200–250cc. If the organic matter is very finely divided, introduce the substance at once into the cylinder, dilute with water to 200cc. Make acid with a 10 per cent. sol. tartaric acid, add 100cc. ethyl ether, and shake the mixture for some time. Let the ether separate and pipette it off into an evaporating dish. Repeat the process of extracting with the ether, the second, and if necessary, the third time, using smaller quantities of ether. Unite the ether extracts. Render the ether sol. *slightly* alkaline with an alcoholic solution of KOH, stir very thoroughly, and allow the ether to evaporate *spontaneously*. This leaves the trace of hydrocyanic acid in combination with potash, as, a fixed salt. Transfer the residue from the ether extract to a large test tube. The tube should be provided with a stopper with double perforations. Through one pass a *well fitting* glass tube, and terminate it at the under surface of the cork; through the other perforation pass a well fitting glass tube whose lower end is drawn out to a very fine point, and let it extend to the bottom of the test tube. Connect the tube which reaches to the bottom of the test tube with a hydrogen generator. The other and shorter tube is connected with a Liebig's bulb containing 25cc of a mixture of 3 pts. of yellow amononia sulphid and one pt. NH_4OH . Make the ether residue in the test tube acid with tartaric acid. Make the connections as above described, and pass a slow stream of hydrogen through the sol. for 30–45 min. Break the connection after the gas has passed sufficiently long, transfer the am. sulphide sol. to a large watch glass, and allow it to evaporate high over a free flame. By this process the hydrocyanic acid which passes over with the hydrogen gas is transformed into am. sulphocyanate. When the am. sulphide sol. has been completely decomposed by evaporation, take up with distilled water

(10cc), filter through a small filter, if necessary, and test the sol. for am. sulphocyanate with ferric chloride. By this process we have succeeded in finding one part of hydrocyanic acid in 200,000 parts of water and organic matter. The method is especially recommended in cases of toxic analysis, where the ferro and ferri-cyanides may be present.

1.4 DIAMINO-CYCLOHEXANE. By W. A. NOYES AND H. H. BALLARD.

[ABSTRACT.]

The chloride was prepared from succinylsuccinic ester by saponification with sulphuric acid formation of the dioxime, and reduction with sodium and alcohol. Solutions of a mixture of equivalent quantities of the amino-chloride and sodium nitrite evolve on heating nearly two atoms of nitrogen. The same is true of a solution of the amino nitrite, prepared by adding silver nitrite to the amino chloride.

The products of the reaction as deduced from their chloroplatinates are 1.4 amino-hydroxy-cyclohexane and λ^3 tetrahydro-aniline.

ON A CASE OF STEREO-ISOMERISM IN THE HYDRAZONES OF BENZOIN. By ALEXANDER SMITH.

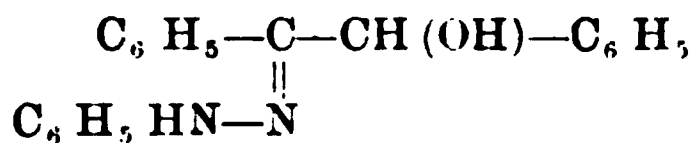
Only four or five cases of isomerism have as yet been discovered among the hydrazones. In each case the two isomers are made in a similar manner and possess similar chemical properties, indicating identity in constitution. In each case, however, the isomers may be distinguished by difference in solubility, melting point and stability. The two hydrazones of benzoïn described in this paper are related to each other in the same way, and, therefore, fall into line with the previously described cases.

Both are formed when benzoïn and phenylhydrazine are heated in alcoholic solution, while the β -hydrazone alone is produced when the ingredients are heated without any solvent.

The α -hydrazone melts at 158° – 159° , is very stable in comparison with the other variety, and is only one-fourth as soluble in alcohol.

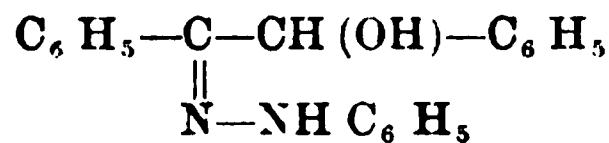
The β -hydrazone melts at 106° , and is easily decomposed, even by prolonged heating with alcohol.

According to Hantsch & Werner's theory, they should receive the formulæ:



α -Hydrazone—

Stable. M. P. 158° – 159° .



β -Hydrazone—

Unstable. M. P. 106° .

CAMPHORIC ACID. By W. A. NOYES.

[ABSTRACT.]

When methyl sodium camphorate is treated with phosphorus oxychloride and the product obtained is treated with ammonia, an amide having the

formula $\text{C}_8\text{H}_{14}\begin{cases} \text{CO}_2\text{CH}_3 \\ \text{CONH}_2 \end{cases}$ is obtained. When this amide is treated with a

solution of sodium hypobromite, an amine, probably of the formula

$\text{C}_8\text{H}_{14}\begin{cases} \text{CO}_2\text{CH}_3 \\ \text{NH}_2 \end{cases}$ is obtained. The study of these compounds is still in

progress, and it is hoped that others may be obtained from them which will throw new light on the structure of camphoric acid.

THE DETECTION OF STRYCHNINE IN AN EXHUMED HUMAN BODY. By W. A. NOYES.

[ABSTRACT.]

The stomach, liver, and a portion of the intestines of a child were submitted for examination on April 26th of this year. The child died on June 23d, 1892, and was buried the following day. The body was exhumed on April 25th, 1893. A small amount of strychnine was recovered and was identified by the reaction with potassium pyrochromate and sulphuric acid, by the bitter taste, by the crystalline form, by the crystals obtained from the chloride with potassium chromate, and by the effect of a

small portion on a small frog, The frog died after developing the tetanus characteristic of strychnine poisoning. The case is of interest because of the length of time which elapsed before the body was exhumed, there being few, if any, cases recorded where strychnine has been found in an exhumed body after so long a time; also, because a considerable portion of the strychnine was retained in the fatty matter and required different means from those usually employed for its separation. A full account of the case will appear in the Journal of the American Chemical Society.

THE ABSORPTION OF POISON BY DEAD ANIMAL TISSUE. By P. S. BAKER.

The alarming frequency of the criminal use of arsenic has led to the study of its effects on the bodies of living and dead animals.

There has been reason to believe that arsenic was introduced into the bodies of men after death, and that involved the investigations of the courts in more or less confusion. Inquiries have therefore been made as to whether arsenic may or may not be absorbed by the corpse from external sources, and the answers to these inquiries have never been satisfactory.

The author has found by numerous experiments on cats that arsenic injected under the skin, from twenty to thirty minutes after death, will penetrate to the internal organs; but if the injection be made later than seventeen hours after death, it could not be found in the internal organs.

The work is still in progress to answer several questions involved in the study.

(ON THE VARIATION OF STRENGTH OF TIMBER AT DIFFERENT PARTS OF THE CROSS SECTION OF THE TREE. By PROF. T. GRAY.

[ABSTRACT.]

In Bulletin No. 8, of the Forestry Division of the U. S. Department of Agriculture, Prof. J. B. Johnston refers to this subject in connection with a series of tests on long-leaved pine. Prof. Johnston's experiments showed a variation of about 12 per cent. of the average tensile strength, the maxi-

mum being, for butt logs, at least, about one-third of the radius from the center of the tree.

A few weeks ago while making some tests of the strength of burr oak and white oak, I was rather surprised to find a variation of tensile strength of much greater amount than that obtained by Prof. Johnston for pine. In the case of the white oak the strength varied from 12,000 pounds per square inch at about one and a half inches from the surface of the tree to about 24,000 pounds per square inch at a similar distance from the center. The log was about ten inches radius and the variation was nearly uniform from the outside to the center. The burr oak showed a similar variation, but unfortunately the record of some of the tests, taken when I was unable to attend personally to the matter, have been lost. I have since made similar tests on water oak and on red oak. The results in the water oak show no decided variation across the sections. The average strength was about 14,000 pounds per square inch, and as nearly uniform as is to be expected in tests of timber. The red oak was also much more nearly uniform in strength across the sections than the white oak, but in this case there was good evidence that the outside wood was the stronger, especially on the side of the tree which had the larger growth. The variation in this case was from about 15,000 pounds on the square inch at the center to 18,000 pounds on the square inch at the outside. The stronger timber was, however, in this case, confined to about three inches of the outer end of the radius.

ON AN AUTOGRAPHIC METHOD OF TESTING THE MAGNETIC QUALITIES OF IRON.
By PROF. T. GRAY.

[ABSTRACT.]

At last Christmas meeting of the Indiana Academy I gave a brief description of some experiments which I had made on the magnetic qualities of iron and of the results I had obtained in these experiments, which were of a preliminary character. The general principle of the method was to deduce the magnetic properties of the iron from the electro magnetic inertia of a circuit composed mainly of a magnetizing coil surrounding the iron. This electro-magnetic inertia is evidenced by the relative values at each instant of the impressed e. m. f. on, and the current flowing through

the circuit when one or both of these quantities is varying. Since that meeting I have been successful in making use of an autographic device for recording the variations of the current during its rise from zero to a maximum immediately after the circuit is closed on a constant battery. The e. m. f. is in this case constant, and the variation of the current indicates the electro-magnetic inertia, and consequently, magnetic quality of the iron.

The autographic apparatus consists of a modification of the Thomson siphon recorder, used for submarine telegraphy. A rectangular coil of a few turns is suspended between the poles of a powerful electro-magnet which is separately excited. The coil is made to form part of the electric circuit containing the magnetizing coil, and hence, as the current varies in the circuit, the coil turns between the poles of the magnet. A long, glass siphon pen records the motion of the coil, or rather its position at every instant, on the record sheet of a chronograph. We thus get a curve of which the abscissæ are intervals of time from the instant of closing the circuit and the ordinate strength of the current at the end of these intervals of time. This curve must be expressed by the equation $L\frac{dc}{dt} + RC = E$ where L is the coefficient of electro magnetic inertia of the circuit, R the resistance, C the current and E the impressed e. m. f. The product RC represents the e. m. f. required to keep a constant current C flowing through the circuit, and $L\frac{dc}{dt}$ represents the back e. m. f., due to self-induction. We may put the equation in the form $L\frac{dc}{dt} = E - RC = e$, or, $Ldc = edt$. The quantity e at any instant is the difference between the ordinate at that instant and the maximum ordinate of the curve when the impressed e. m. f. curve is drawn to such a scale as to coincide with the maximum value of the current curve. We then get e readily from the curve. Also edt is the increase of induction in time dt , and therefore the area included between the current curve and the e. m. f. curve up to any instant gives, when multiplied by the proper constant, the total induction up to that instant. These different inductions, when expressed graphically, with magneto-motive forces derived from the strength of the current and the proper constants of the magnetizing coil as abscissæ, give the ordinary magnetization curve. From this curve the permeability of the material, the dissipation of energy in cyclic action, and so forth, can be readily derived in the ordinary way.

THE VALUE OF THE STEAM PIPE WITHIN THE SMOKE BOX OF A LOCOMOTIVE, AS A MEANS OF SUPERHEATING. By Wm. F. M. Goss.

The pipe connection, by which steam is conveyed from the boiler to the engines of an American locomotive, begins at the throttle valve within the dome of the boiler, and extends forward along the inside of the boiler until it finally passes out through forward head into the smoke box. Here it receives a fitting known as the "T-head," from which branch pipes leading to the cylinders on either side of the machine. The T-head and the two branch pipes are exposed to the temperature of the smoke box, which, when the engine is in action, is several hundred degrees higher than the temperature of the steam within the pipes, and it is therefore evident that the latter must receive some heat from the smoke box in its passage through these pipes. The amount of heat thus transmitted, however, has always been a matter of speculation.

Designers of compound locomotives have often arranged an enlarged pipe within the smoke box to serve in the double capacity of receiver and re-heater, the expectation being that the steam exhausted from the high pressure cylinder would be dried, or even superheated, by its passage through this pipe in its course to the lower pressure cylinder. To throw some light on the extent of the drying or superheating effect, as well as to settle another question at issue, the following experiment was made upon the Purdue experimental locomotive:

A thermometer having been inserted in the T-head, another in the middle of one branch of the steam pipe, and a third in the saddle close to the valve-box, the locomotive was run with the throttle partially open, the drop in pressure from the boiler to the pipe being sufficient to superheat all of the steam at the lower pressure. It is evident that a change in the quality of the steam as it passed from one thermometer to another in its course to the cylinders would be at once detected by a change of temperature.

The conditions of the test were maintained for half an hour or more before observations were taken, after which time the thermometers were read and other observations taken simultaneously at five minute intervals for a second half hour. The following is a summary of results:

Smoke box temperature	700. ° F
Increase of smoke box temperature over temperature of steam in the boiler	345. ° F
Temperature in T-head	335.30° F

Temperature in middle of steam pipe	339.65° F
Temperature in saddle	327.87° F
Pressure in dry pipe by gauge	70 lbs
Temperature of saturated steam at pressure in dry pipe	315.68° F
Approximate time occupied by the steam in passing the steam pipe	0.1 seconds

It will be seen that the temperature of the steam was increased 4.4° F in passing half the length of the branch pipe, which is equivalent to a gain of 8.8° F in its passage through the whole length of the branch pipe. The transfer of a quantity of heat represented by this increase of temperature would affect moist steam by increasing its dryness about 0.5 of 1 per cent., an amount too small to affect the efficiency of the whole machine to any measureable extent.

The thermometer in the saddle indicated a temperature of 9.4° F lower than the temperature in the T-head, and 18.2° lower than the presumable temperature at the end of the steam pipe, so that, from the T-head to the cylinder, there is no gain, but an actual loss of heat by the steam. This effect is to be accounted for in the fact that the mean temperature within the cylinders is much lower than the temperature of the incoming steam, which, combined with the effect of radiation from the saddle, operates to lower the temperature of the iron which surrounds the steam in its passage through the saddle. It is certainly clear that the cooling effect of the saddle more than offsets the gain in heating effect secured from the smoke box.

The conditions were varied and all of the work repeated several times with the same general results. The figures given represent the test giving the greatest heating effect.

Enlarging the pipes within the smoke box would have a beneficial effect in increasing the action herein considered, since it would add to the extent of heating surface and lengthen the time occupied by the steam in passing the same, but, as a practical matter, a limit to such enlargement is soon reached.

As affecting the reliability of results, it may be said that the thermometers used have a range of from 100 C to 200 C and read to $\frac{1}{3}$ of a degree. They were inserted in long tubes, and at the T-head and at the middle of the steam pipe these tubes were protected by allowing steam to flow past them under pressure into the atmosphere. Before being used the thermometers were carefully compared when in the identical tubes used upon

the locomotive by subjecting them to saturated steam of about the same temperature as that recorded in the experiment. The reading of one was accepted as standard, and the errors of the other two determined.

AN EXPERIMENTAL STUDY OF THE ACTION OF THE COUNTERBALANCE IN LOCOMOTIVE DRIVE WHEELS.. By WM. F. M. GOSS.

In the mechanism of the locomotive, the mass of the reciprocating parts (piston, piston rods, crosshead, etc.) is balanced to a greater or less extent, by the addition of masses to the drivers, known as counterbalances. But the counterbalances move in circular paths, so that it is only the horizontal component of the radial force derived from them that serves to neutralize the effect of the reciprocating parts; while the vertical component of these counterbalances is an unbalanced force causing the pressure of the drivers on the rails to vary with every revolution. The extent of the disturbing effects of this unbalanced vertical component has long been a question of serious concern to the locomotive designer; but in this country, at least, they have found but little light to guide them. It has been difficult to ascertain enough of the conditions existing at any phase of the wheel's motion to serve as a basis for satisfactory mathematical work, and no solution has as yet been presented which will enable the designers to anticipate effects which are incident to the action of the completed machine. Practical demonstrations, however, are not wanting. Bridges are shaken until they fall, and rails are actually crooked under the stresses brought upon them by locomotives passing at high speed.

It occurred to the writer that in the case of the Purdue experimental locomotive a study could be made of the extent of this changing pressure of the wheel upon the rail, by feeding a wire under the wheel and by making use of the resulting variations in its thickness. This was first accomplished last spring, but the most satisfactory results have been obtained during the term just closed. A light mark made with a cold chisel across the face of the wheel leaves its impression in the wire and furnishes the desired reference point, by means of which particular effects may be connected with their appropriate wheel positions.

The following, concerning one of the rear drivers, may be of interest:

The pressure which this wheel exerts upon the rail when at rest is 7 tons, and its counterbalance, reduced to the radius of the crank pin, weighs

400 pounds more than is necessary to balance the revolving weights at the crank pin, that is, so far as vertical effects are concerned, the wheel is 400 pounds out of balance.

Wires which have passed under the wheel at speeds below 30 miles do not vary greatly in thickness. At a speed of 59 miles (333 rev.) however, a very short section of the wire is left entirely round, showing clearly that at this speed there is an instant in the revolution of the wheel when it exerts absolutely no pressure upon the rail, and making it fair to assume that there is another instant when it exerts double the pressure it transmits when at rest. In other words, in half a revolution, occupying less than a fifth of a second, the wheel pressure varies from nothing to 14 tons. The increment of the pressure is really more rapid than this, for it is found that the maximum lift occurs after the counterbalance has passed the vertical by a considerable angle. During the upward action the wheel lags and during the downward action there is a corresponding acceleration.

For speeds above 59 miles the undamaged portion of the wire is longer. Thus for 65 miles it is about 45 inches, showing the wheel to be off the rail for almost a quarter of a revolution, and its return to the rail is correspondingly rapid. The destructive effect of such a blow is enormous.

Complete wires are shown, also a diagram of a typical wire taken at 65 miles in which the vertical scale is greatly increased and the horizontal scale is diminished as compared with the actual dimensions of the wire. This diagram shows, as do all the wires, the lagging of the wheel in its upward motion and the rapidity of its return to the rail.

In addition to the immediate results yielded, this experimental investigation may serve as a means to a more complete mathematical analysis of the subject. This latter phase of the work is now being very skillfully developed by Mr. Daniel Royse, M. M. E., Junior member of the A. S. of M. E., to whom, also, I am indebted for numerical results derived from a study of many wires.

THE COLUMBIAN MUSEUM. By JOHN M. COULTER.

[ABSTRACT.]

An explanation of the organization of the Columbian Museum and its scientific possibilities.

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